A Systematic Review of the Use of Augmented Reality (AR) and Virtual Reality (VR) in Online Retailing

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Abstract

While online shopping is popular, the online retail experience has various limitations. For example, customers may receive goods that are different from what they saw online after purchasing the goods. They may also find it difficult to return the goods that they are dissatisfied with. For online retailers, homogeneous competition, where many sellers sell the same product, has always been a major issue. Augmented and virtual reality (AR/VR) technology has been widely suggested to improve the online retail experience. This technology can enhance the experience of customers by improving how they interact with retailers, providing the latter with a competitive advantage. However, despite these benefits, AR/VR technology is not widely used by online retailers. This study investigates how AR/VR technology works and its potential impacts on online shopping. Based on the findings from a systematic literature review using thematic analysis, I found that while AR/VR technology offers many benefits to retailers and their customers, various obstacles, especially technical ones, exist to expanding their use. At the same time, the use of AR/VR technology also introduces new risks into the online shopping environment, which need to be managed.

Key words: augmented reality, e-commerce, mixed reality, online retailing, online shopping, systematic review, virtual reality

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signature: 

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Chapter 1: Introduction

Augmented reality (AR) and virtual reality (VR) are technologies which have been widely predicted to have an impact on business. For example, more than twenty years ago, Leston (1996) argued that AR/VR would benefit online retailers by providing virtual stores with similar in-store services as physical stores. However, AR/VR are still not widely used by organizations, possibly because there are relatively high entrance barriers from a technical perspective (Warburton, 2009).

The purpose of this study is to conduct a systematic review of how AR/VR may create value for online retailers by overcoming the limitations of traditional e-commerce. There are two motivations for this research. First, e-commerce is growing tremendously and may even take over traditional, face-to-face retail in the near future. However, the functionalities and features of most online retailers have not changed much over the last decade or so, which is surprising given the level of innovation in improving the user experience online. Second, this study will guide future researchers and practitioners by integrating what we know on this topic and by offering a list of future possibilities.

This dissertation investigates how AR/VR technology works, its potential impacts on online shopping, and the reasons for its low adoption. The dissertation begins by explaining what AR/VR is, the contexts it has been used in, and what its impacts have been so far. Examples are provided to help readers understand the technologies' application in industry. Next, the dissertation describes the development of online shopping over the last twenty-five years, the key challenges faced by online retailers and shoppers, and models for understanding the experience of online shopping. Then, the systematic review methodology is described with the goal of integrating research on the use of AR/VR in online shopping.

The findings chapter summarizes what was found during the data collection. In the discussion chapter, the findings from the review are mapped to models of online shopping experience to understand how AR/VR may contribute to online shopping. That dissertation concludes with suggestions for future researchers. It is hoped that this research will trigger further study of AR/VR and e-commerce by other researchers in the future.

Chapter 2: Background & Literature Review

In this chapter, I will discuss e-commerce, augmented and virtual reality technologies (AR/VR), and how these two technologies can be combined. The definitions of e-commerce and AR/VR will be briefly explained from both technical and practical perspectives. This section will also include key ideas from previous researchers to give readers a good understanding of e-commerce and AR/VR. The chapter also includes examples about how these two technologies are used. The goal of this chapter is to allow readers to understand the background of this research.

2.1 E-commerce

E-commerce is becoming more popular globally, with more people accepting it as their new way of shopping (Smith & Linden, 2017). E-commerce began in 1995 as a relatively narrow concept that meant selling goods online (Laudon and Traver, 2016). Both retailers and consumers can gain many benefits from online retail: retailers have increased their income by 16% on average, while consumers have benefited from an increase of 35% to 40% in the choice available to them (Quan & Williams, 2018).

After years of rapid development, e-commerce has expanded to include tangible and intangible merchandise (Laudon & Traver, 2016). Intangible merchandise includes digital products, while tangible merchandise refers to physical products. Lee and Lin (2005) define e-commerce as providing an e-service to customers. The quality of this e-service influences individuals' consuming behavior in a virtual environment (Lee & Lin, 2005). The concept of "shopping quality" can be divided into multiple dimensions that contributes to customers' shopping experience, such as navigation, information search, response time, product delivery and interactions with online sellers (Lee & Lin, 2005).

There are a few varieties of e-commerce. B2C (business to consumers) retailers sell to individual customers, while B2B (business to business) firms focus on organizational customers. B2B firms do not place as much importance on social media marketing as a strategy to develop relationships with their existing customers, compared to the B2C firms, because B2B places higher emphasis on one-to-one communication (Iankova, 2018). In contrast, B2C firms focus on communicating one-to-many, so they tend to invest in social

media marketing (Iankova et al., 2018). Compared to the B2C market, B2B e-commerce operates in a more complex scenario, because B2B firms have assure their customers that supply and demand will be matched in their marketplace so that the latter can fulfil their own customers' orders (Ordanini &Pol, 2001).

G2B/C refers to Government to Business/Consumer e-commerce. An example is a government's electronic procurement system. Moving procurement online reduces distrust between sellers and the government (Sambasivan et al., 2010). It also increases the public service's information transparency and leads to cost savings (Alshehri & Drew, 2010). C2C is defined as Consumer to Consumer, such as the TradeMe platform, where individuals buy goods from other individuals.

While e-commerce encompasses the variety of business models mentioned above, this study focuses on B2C online retailing. The rest of the dissertation will focus on research about this type of e-commerce.

2.1.1 Changes in E-commerce over the last 25 years

The concept "E-commerce" was born out of the Internet boom around early 1990s (Grönlund & Horan, 2005). During the early stages, the Internet was used only as a marketing tool (Kraemer & Dedrick, 2002) or to enhance communication efficiency. E-commerce often began over bulletin board system (BBS) that allowed users to exchange information (Kaplan & Haenlein, 2010). Shortly after that, along with the rapid development of Internet, people start trading activities on the Internet around the mid -1990s. One example was a community for people to trade music online (Nieckarz, 2005). This could be seen as a prototype of C2C and B2C platform. Some famous companies, such as EBay and Amazon, were started in the mid-1990s and experienced rapid growth.

Today, e-commerce has evolved and moved onto social media platforms, such as Facebook or Instagram (Kaplan & Haenlein, 2010). This new development has been called "social commerce", as it provides a chance to transform e-commerce from a product-oriented environment to a social and customer-centric environment (Huang & Benyoucef, 2013). Social commerce is an extension of traditional social media, combining e-commerce with online social interaction. One example of social commerce is the advertisement of products and services by 'influencers' or internet personalities on Facebook, Instagram, and other

platforms. At the same time, the broad acceptance of the mobile phone has led to mobile commerce, also known as “mCommerce”, where individuals engage in trading activities on mobile websites or apps (Troutman & Timpson, 2008). The use of wireless networks and devices has made e-commerce more accessible, increasing the pool of potential consumers. M-commerce also provides other advantages for online sellers, such as identifiability, which means that it is easier to: a) deliver targeted advertisements to individual customers since mobile devices are usually not shared by individuals, and b) maintain a constant connection with customers, because of the “always on” attribute of mobile devices (Mahatanankoon, Wen & Lim, 2005). Some purely mobile shopping platforms have emerged, such as Pinduoduo, which was created in 2017 in China (Xin et al., 2017).

2.1.2 Challenges with E-commerce

E-commerce is a very competitive space, so firms often look for new ways to improve their e-commerce operations (Rask & Dholakia, 2001). At the same time, e-commerce today has many limitations for both consumers and e-commerce retailers. Key challenges in e-commerce include the agility of the platforms (whether they can change to fit the changing business environment), trust among buyers and sellers, and the reputation of buyers and sellers.

Consumers face at least three challenges. First, the goods they purchase may not match the online images they saw before buying the good (Gilbride, Currim, Mintz, & Siddarth, 2016). It is not possible for every seller to take photos themselves of every product they sell. Thus, sellers usually use photos provided by manufacturers or professional photographers. This means that most of the images of products from different online store may be from the same source. Moreover, these photos are often artistically modified to make them look appealing. Therefore, it is possible for consumers to purchase products that do not match the photos on the online store. Secondly, returning goods may be difficult and annoying for consumers, especially perishable items such as food, which have a limited shelf-time. It is neither economical nor practical to return food back to sellers. The third challenge is delivery to customers living outside major urban centers. E-commerce retailers find it difficult to deliver to consumers living in remote locations because they will have to incur higher shipping fees, especially if they have committed to a “free shipping” policy. If sellers do not want to incur the higher charges, consumers will have to pay the shipping fees,

which could potentially lower their desire to buy. In addition, time-sensitive goods, such as fruit and seafood, cannot be delivered to remote areas. These three challenges may make online shopping an unpleasant experience, increasing customer dissatisfaction.

Online sellers also face some challenges. Firstly, a common issue for is “last-kilometer” or “last-mile” delivery (Patier et al., 2014; Nguyen, de Leeuw, & Dullaert, 2018). Most logistic delivery systems find it time-consuming, expensive or impossible to deliver goods into customers’ hands, mostly due to geographical reasons. Customers living in remote areas may not be easily accessed by driving, or may have other forms of poor infrastructure (Patier et al., 2014). The prohibitive price of shipping may thus suppress customers’ potential consumption ability.

Second, while physical stores can easily show their scale, online stores cannot do so. For physical stores, people can directly see and feel how massive and big the physical store is simply by looking at it. Showing off one’s size is important to a store, because often store size is seen as evidence of a stores’ longevity or capability. In contrast, customers who visit online stores view them through the screens of their devices; this makes it difficult for online retailers to assure customers of their credibility. In the online context, cognitive-based trust can be affected by the design of the Web site’s interface. This is because first-time visitors to an online store largely form their first impression of the store from the interface they see (Lim et al., 2006). However, no matter how fancy a store’s interface is, consumers are not likely fully trust a store based only on its interface; they will usually require some empirical proof, which has the same effect as size or quality of fittings in physical stores. For physical stores, growth is easily demonstrated, as it only needs to get bigger and improve its appearance. But for online stores, growth is not as easily presented to consumers, who are limited to what they can see through a fixed-size screen.

Operating costs are another challenge for online stores. They often have to adopt new technologies to gain competitive advantages (Anand & Kulshreshtha, 2007), such as increased efficiency and reduced errors. These technologies need to be supported by a large group of IT employees, who usually receive relatively higher salaries than employees in traditional retailers. The need to invest in new IT and hire higher-salary staff may mean that the operating costs of online sellers could be higher than traditional stores. However, this depends on the scale of the online store or traditional store: online stores can support a

higher volume of retail without incurring higher wage costs, unlike traditional stores that have to hire more shop-floor staff and rent more facilities. One way that online retailers can reduce their operating costs would be to use cloud computing services (Lackermair 2011), as doing so would increase their scalability, flexibility and cost-efficiency. Another approach for online retailers would be to ship their goods so they are sold on third-party platforms such as Amazon Marketplace and Taobao/T-mall.

Fourth, e-commerce retailers find it difficult to distinguish themselves from their competitors. This has been termed “homogenized competition”, a situation where many sellers sell the same kind of product on the same platform (Kung, Monroe, & Cox, 2002). Homogenized competition occurs because of the commoditization of products online- consumers can easily compare product features and buy from the cheapest seller. This leads in turn to sellers focusing on selling standardized, popular products at the lowest possible price. This occurs especially for “3C” products (computer, communication and consumer electric products), such as laptops and smartphones (Ding, Huo & Campos, 2017). As a result of homogenized competition, the discoverability of an online store becomes an area of concern for many online retailers (Song, Kim, Jones, Baker & Chin, 2014).

To conclude, the challenges that buyers face- the “last mile delivery” issue, the lack of product diversity, the difficulty of verifying quality before buying, and so on - can be summarized under the category “shopping experience”. In the next section, I will present the background of AR/VR technology and then discuss how it can be used to overcome the challenges of e-commerce.

2.2 History of VR and AR

The term virtual reality (VR) was coined in 1989 by Jaron Lanier (Steuer, 1992). VR refers to a system which usually includes a computer capable of real-time animation, controlled by a user through hardware, such as motion-tracking gloves and a display screen that allows the animation to be displayed (Steuer, 1992). The term augmented reality (AR) can be defined as a technology that overlays digital information on objects or places in the real world for the purpose of enhancing the user experience (Berryman, 2012). Table 1 lists various definitions of AR and VR.

Study	Definition
Steuer, 1992	Virtual Reality is electronic simulations of environments experienced via head-mounted eye goggles and wired clothing enabling the end user to interact in realistic three-dimensional situations.
Greenbaum, 1992	Virtual Reality is an alternate world filled with computer-generated images that respond to human movements. These simulated environments are usual& visited with the aid of an expensive data suit which features stereophonic video goggles and fiber-optic data gloves.
Azuma, 1997; Azuma et al., 2001	1. Combines real and virtual objects in a real environment; 2. Registers (aligns) real and virtual objects with each other; 3. Runs interactively, in three dimensions, and in real time.

Table 1: Definitions of AR & VR

Augmented reality and virtual reality are not very different both technically and in the way they are used. Looking at the functions of AR and VR, both are computer programs that create virtual objects and render them, both need motion trackers to be functional, and both require high-end hardware as a platform. Caudell and Mizell (1992) suggested that the primary difference between VR and AR is in the complexity of the projected graphical objects. So, despite some technical differences between AR and VR, both technologies are similar conceptually. Thus, it would be better to consider them jointly as a single emergent technology- "AR/VR".

Various reasons have motivated researchers to continue studying AR/VR. At the beginning of the 21st century, the rapid growth of new types of computer hardware and software, such as Web 2.0, encouraged researchers to build on them to improve AR/VR technology (Voogt et al., 2013). Another motivation for researchers is to study how AR/VR can help with issues such as remote learning and multiuser communication. A third motivation for researchers to continue developing AR/VR could be the human instinct of constantly looking for new ways to apply new tools. AR/VR in this case is regarded as an innovative tool with great potential (Voogt et al., 2013). This has been recognized as far back as 1995, when Hawkins described AR/VR as the "future of fun" because of its potential applicability in many domains (Hawkins, 1995). AR/VR research has also been motivated by research in neuroscience, such as Lécuyer's research (Lécuyer et al., 2008) on brain-computer-interfaces. Some neuroscientists studied the use of more efficient brain-signal processing techniques, which may possibly make controlling AR/VR less complex. These techniques allow users to use their own brains to interact with the computer instead of using controllers. This could

significantly simplify the controlling procedures, thus improving the overall experience of interacting with AR/VR.

After 2010, AR/VR started featuring in various consumer markets. For example, in the video game industry, new genres of AR games, like Pokemon Go, were launched (Serino et al., 2016). Other AR/VR applications were developed for domains such as education, remote learning, and military training (Van & Poelman, 2007). By 2010, VR was a mature technology but was not yet a mass phenomenon (Carrozzino & Bergamasco, 2010).

Two recent relevant developments are the rapid growth of mobile shopping, or "mCommerce" (Troutman & Timpson, 2008), and improvements in mobile network technology, from 3G to 4G and soon 5G. Traditionally, VR systems make use of the computing resources of personal computers, with fixed-line Internet connections. This limits their use to contexts such as gaming and training. Mobile devices that use current 4G networks will only be able to deliver lower resolution video, which will result in a poor-quality VR experience, or wait for the file to be downloaded before running the VR system. Some firms, such as HTC, Vive and Oculus, are offering VR headsets linked to mobile devices: individuals view AR/VR footage by inserting their mobile device into the headset and then turning on an app on their mobile device for displaying mixed reality (both augmented and virtual reality) footage (Lu et al., 2016). This approach has been used by Alibaba for its Buy+ shopping service and could represent a possible future of mobile online shopping (Cao, 2017). However, 5G wireless networks will have the bandwidth and latency requirements to run VR files in real time (Bastug et al., 2017).

2.3 How AR/VR works

The actual implementation of AR/VR requires a software program and hardware components (a processor and a display device) to work together to determine the level of immersion (Bowman & McMahan, 2007). For VR, this requires the creation of a three-dimensional (3D) image, so that users feel they are fully immersed in an environment.

Figure 1 below show the basic method for creating an impression of a 3D image: take a picture with a camera on the left and combine it with another picture taken by a camera on the right (Fig. 2). The result will create the perception of 3D because of how the human eye

works (Block & McNally, 2013). VR headsets work according to the same principle: the left image is projected into the user's left eye and vice versa.

Figure 1: Left & Right eye camera position (Block & McNally, 2013, p. 6)

Figure 2: Left and Right eye's view (Block & McNally, 2013, p. 10).

The explanation above is illustrated below with an example. The example is based on the YouTube tutorial, "How to Make an Anaglyph 3D Image in Photoshop That Really Works!" (Graphics, S. 2018).

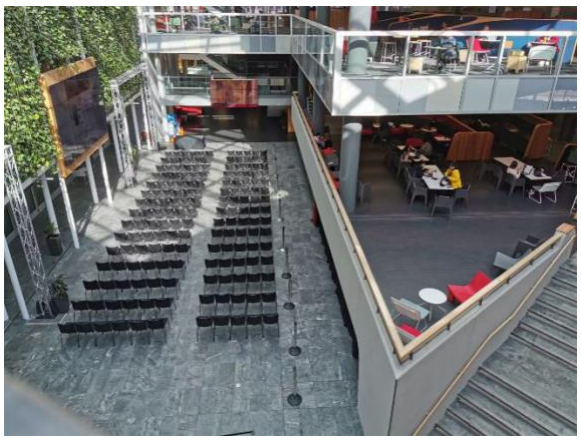

Figure 3: Left Eye View

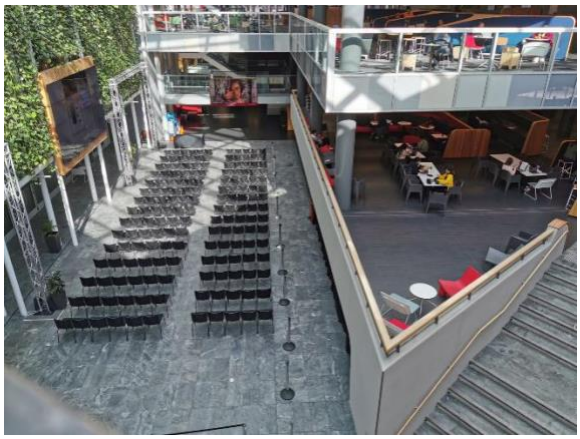

Figure 3-1: Right Eye View

Step 1: Take one image from the left to simulate the view from the left eye. Then, move the camera to the right by 5 centimeters to simulate the position of the right eye and take the second image. The images must be appropriately aligned and matched. This scene (Figures 3 and 4) was taken at from the fourth floor of AUT's WG building.

Step 2: Remove the color red from the left -eye's image, and the colors green and blue from the right-eye's image by deleting the corresponding RGB channel of each image in Photoshop.

Figure 4: Red Channel

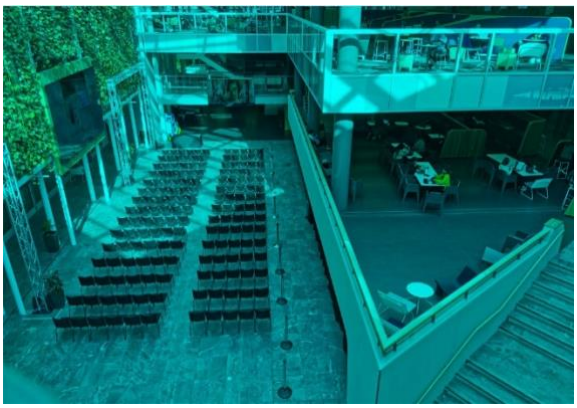

Figure 4 1: Blue and Green Channel

Step 3: Combine the two images, so that one image without the color red is combined with another image without the colors green and blue to re-create an image with the full RGB color range but with a little "red-shift" effect. Then make some movements manually to adjust the relative position of the two images.

Step 4: Use red-blue anaglyphic eyeglasses[1] to view the new image (Figure 5). A 3D effect should be observed.

1 Anaglyphic eyeglasses have different-coloured lenses for each eye (usually red and blue). They are used for viewing images which have been created to show a three-dimensional effect (Wikipedia contributors, 2019)

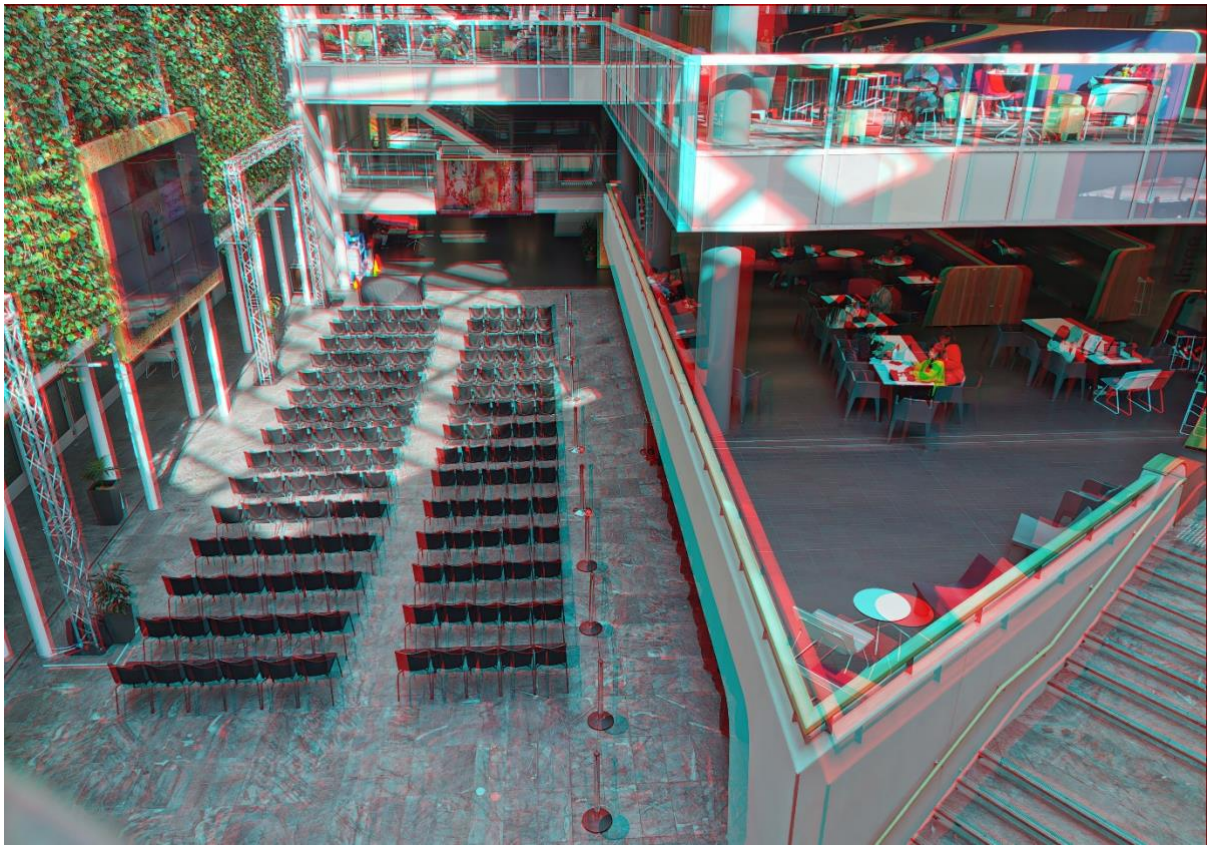

Figure 5: Combine Red Channel with B&G channel

VR systems use this same basic approach but at a more intensive scale. VR display monitors need to display two images simultaneously, with one of the images simulating the view from a human's left eye and another from the right eye. Thus, the processor has to process two images from different angles at exactly the same time, and then output two images exactly together without any tolerance for lagging. Lindner et al., explain the challenge of doing this:

> "… (the) computational resources required to generate unique high resolution (around 1080 × 1200 pixels) images for each eye with a fast (60 Hz) minimum refresh rate to prevent motion blur and sickness, along with real-time motion tracking and core application processes" (Lindner et al., 2017, p.407)

For a processor to render multiple images and match them in time simultaneously requires tremendous computational resources, which is a big challenge for VR hardware designers. These hardware difficulties will constrain the speed of development of VR, as well as the public acceptance level and affordability of this technology (Lindner et al., 2017).

Augmented reality technology (AR) works slightly differently from virtual reality (VR). While VR relies on a totally digital environment, AR is based on an environment that combines physical and virtual objects (Berryman, 2012). AR “calculates” environmental attributes using certain algorithms and then uses the results to make it seem as if the object is really in the environment. For example, to use AR on a smartphone, the smartphone has to compare the image-based data it receives from the camera with other data, so that the smartphone can recognize what the camera is “looking” at. Next, the smartphone maps the virtual data onto the physical object or landscape. One way would be to overlay virtual objects on the image so that users view the virtual objects as being part of the real environment. AR technology has been applied in many industries such as education. Figure 6: AR Dinosaur is an example of how AR is used from a tablet, such as an iPad. When the person handling the tablet scans a card on the table, the AR application will capture the direction of light in the setting and the angle at which the device is being held to determine the shadow that will be cast by the virtual object. If the image is animated, these measurements are taken over the predicted path of the object. This information is then used to calculate where to overlay the virtual image. As shown in Figure 6, an animated dinosaur is added onto the screen when the calculation is complete.

Figure 6: AR Dinosaur (Derek, 2017)

2.4 Application of AR/VR

Besides online shopping, AR/VR technology has been used by many different domains. Augmented reality has been used for personal assistance and navigation (Van & Poelman, 2007), training (Basdogan, Sedef, Harders, & Wesarg, 2007) and games like Pokemon Go (Serino et al., 2016). Virtual reality has also been used in computer games, education, and construction, with an example being Construct3D, a mathematics and geometry-based construction tool (Kaufmann &Wagner, 2000). Virtual exhibitions and virtual museums are another area where AR/VR are being used (Schofield et al., 2018). The rapid improvements in AR/VR hardware and software mean that AR/VR will possibly be used in many other domains, because of its high compatibility with many activities.

The benefits of using AR/VR are that it provides direct sensations for certain behaviors. For example, this is useful for training workers in manufacturing processes (Mujber et al., 2004), because AR/VR will enable them to practice their skills in a risk-free environment instead of going to the actual production line without any risk-avoidance experiences. Compared to traditional training methods, virtual or semi-virtual environments may be more cost-effective.

However, there are also disadvantages of using AR/VR. First, the hardware required to use it is quite expensive, because it requires sophisticated processors, displays, motion gloves, and headsets. Second, VR technology may trigger motion sickness for individuals who use it for a long time (Lindner et al., 2017), which could limit the time they can spend in virtual world to carry out training, learning, and so on. Finally, constructing a virtual environment is time-consuming and difficult because it consists of multiple phases such as 3D-modeling, texturing, rendering, camera calibration and testing. (Kanade et al., 1997).

Mixed reality is a good synthesis of AR and VR and can be described as merging the real and virtual worlds (Ohta & Tamura, 2014), where a real scene incorporates a virtual interface. Milgram and Kishino (1994) described mixed reality as “VR-related technologies that involve the merging of real and virtual worlds somewhere along the "virtuality continuum" (Figure 7) which connects completely real environments to completely virtual ones.” Alibaba’s Buy+, a potential way of online shopping in the future, is a good example of mixed reality (Figure 8). Compared to a full virtual reality environment, organizations that choose mixed reality can save some costs since no virtual scene building is necessary. However, the

downside is that the position of the user and the camera is often limited or fixed (Huang et al., 2009) in a mixed reality environment, reducing the freedom of movement of users.

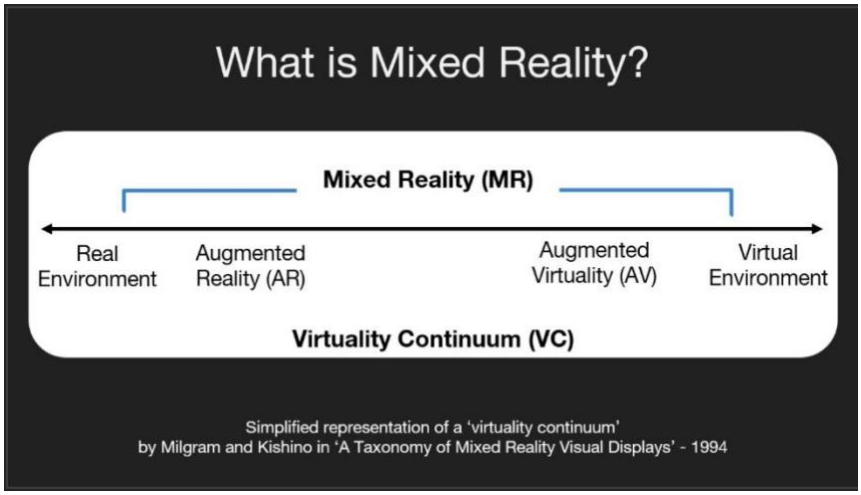

Figure 7: Virtuality Continuum

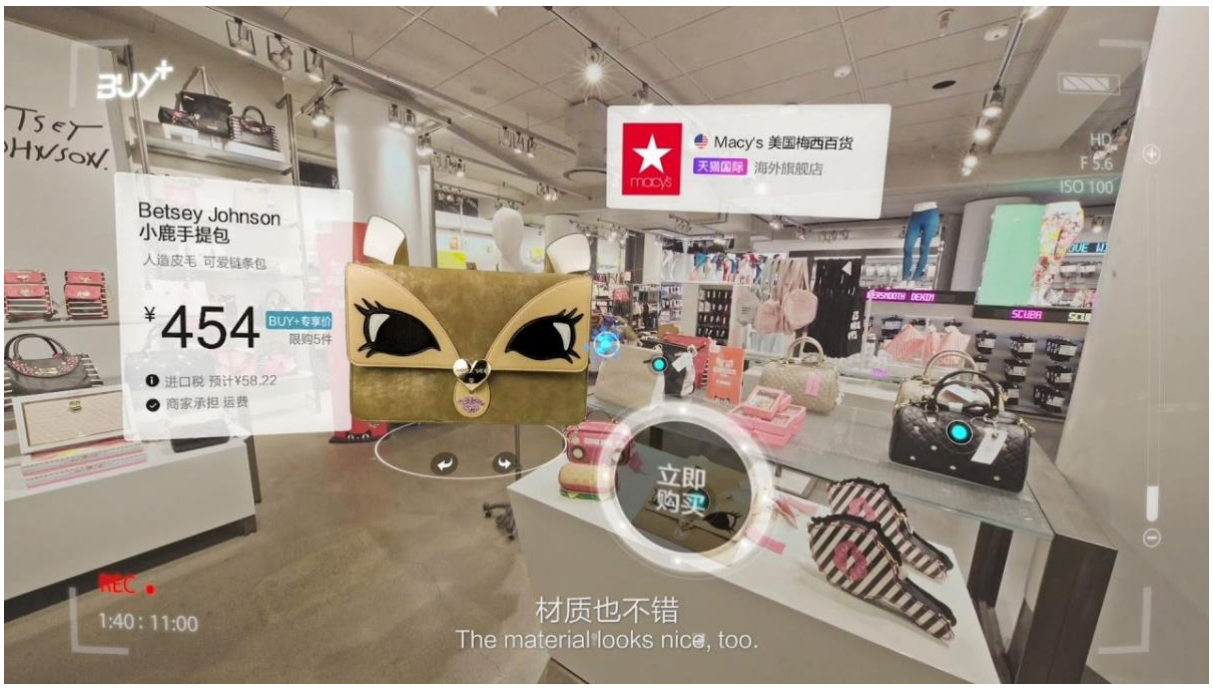

Figure 8: Alibaba's Buy+: an example of mixed reality

2.5 The online shopping experience

Online shopping can be divided into multiple stages (Chen & Chang, 2003). Firstly, it starts with a consumer searching for the good that s/he needs and discovering the online store or website where it is available. This is followed by the buying stage, which includes checking the price, comparing the good with other goods, interacting with the seller online to gather more information about the good to decide whether to buy it or not, and considering the convenience of the payment method. The next step is the after-sales stage, which includes

the delivery of the goods and return procedures if the consumer is not satisfied with the quality of the good. This stage could also include a feedback phase where the consumer comments on the goods and the shopping experience to help future consumers before they make the buying decision.

Customer experience is the internal and subjective response customers have to any direct or indirect contact with a company (Izogo & Jayawardhena, 2018). The online shopping experience has a significant positive effect on online shopping satisfaction (Khalifa & Liu, 2007). Every step in the online shopping activity, such as customer service, quality of goods, price of goods, and delivery time, contributes to the overall experience. An example of a satisfying shopping experience is when a consumer buys a pair of expensive jeans for a low price from a seller who answered all the consumer's questions with a friendly attitude, offered free shipping and delivered the jeans in three days. In contrast, an example of a less satisfying shopping experience is when a consumer spends three hours communicating with an unfriendly seller who charges a high price for the jeans and for shipping, waits two months for the jeans to arrive, and finds out that the jeans do not fit him/her and must be returned.

Researchers have identified many different factors that influence online shopping experience. Chen and Chang (2003) divided the predictors of online shopping experience into three broad factors- interactivity, transaction and fulfillment, which were subdivided further into sub-factors (Figure 9). Within interactivity, "website design" refers both to the logical structure of the website, as well as its appearance. The interactivity factor is relevant for online shopping, while the other two factors are relevant for both online and physical retail stores.

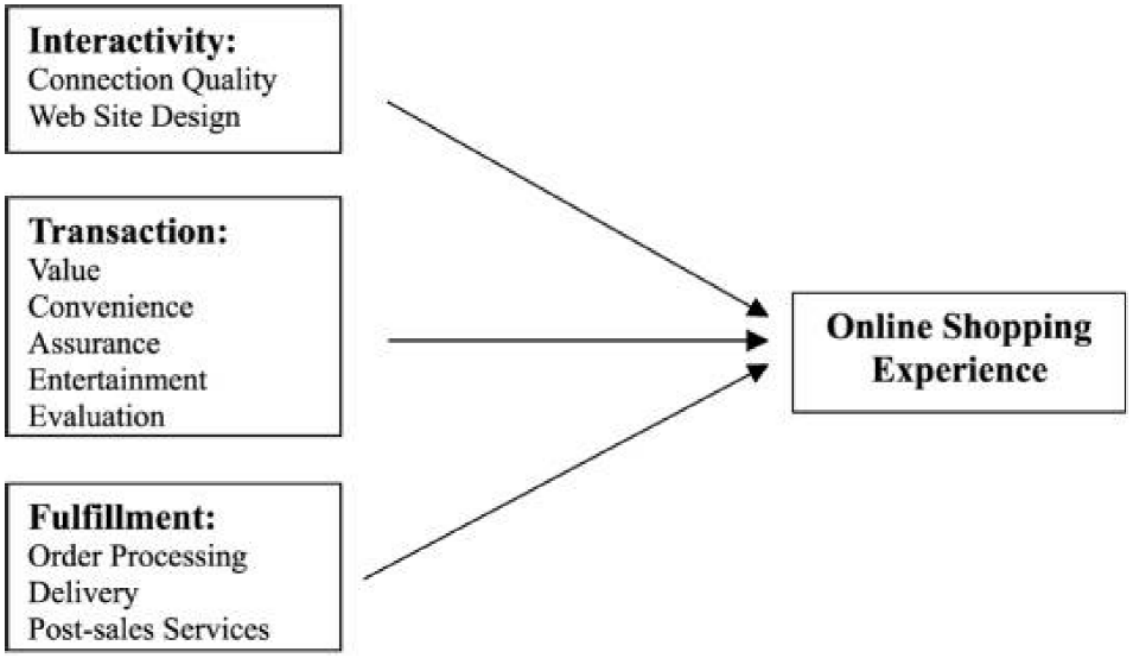

Figure 9: Online Shopping Experience Model (Chen & Chang, 2003, p. 562)

Besides Chen and Chang (2003), other researchers have identified other predictors of the online shopping experience. These are categorized in Table 2. For example, Izogo & Jayawardhena (2018) identified these factors: service excellence, playfulness, and aesthetic quality, which refers to consumers' subjective opinion as to whether the website has a sense of beauty. Magnenat-Thalmann and her colleagues (2011) included pre-visualization as a predictor of an enhanced online shopping experience because it will likely allow consumers to save a lot of effort to imagine what a product looks like. Trevinal and Stenger (2014) proposed that the online shopping experience is better if customers had similar values as the seller; they define this as the "ideological" dimension of online shopping, and list the possible values of consumers as hedonic, gratification seeking, or utilitarian.

Categories	**Factors that influence the online shopping experience**	**Reference**
Technical Issues	Connection Quality	Chen & Chang, 2003
	Hardware capability	Lindner et al., 2017
	Product diversity	Kung, Monroe, & Cox, 2002
	Previsualization	Magnenat-Thalmann et al., 2011
	Accessibility	Swapana & Padmavathy, 2017
User Experience	Website Design	Chen & Chang, 2003
	Entertainment	Chen & Chang, 2003
	Aesthetic	Izogo & Jayawardhena, 2018
	Dis-alignment of image and product	Gilbride, 2016
	After-sale service	Chen & Chang, 2003

	Service quality	Swapana & Padmavathy, 2017
Both user experience and technical	Convenience	Chen & Chang, 2003
	Interactivity	Chen & Chang, 2003

Table 2: Factors that contribute to online shopping experience

In the next section, I will explain the potential impact of AR/VR on these factors to understand how the use of AR/VR influences the online shopping experience.

2.6 Current Applications of AR/VR in online retailing

Figure 10 shows the trendline for the search terms “virtual reality” and “online shopping” and "augmented reality" and “online shopping” on Google. From around 2010, the first combination of keywords began to be searched for more often on Google, increasing steadily until a drop last year. Searches for the second combination of keywords increased significantly in 2008, fell slightly till 2015, and then increased steadily till now. This pattern could be one of the reasons why there is little material available on the use of AR/VR in online retailing before 2008, even though both B2C e-commerce and VR/AR have independently existed for more than ten years before that. This search pattern suggests that using the period 2008 to 2019 for my review was appropriate.

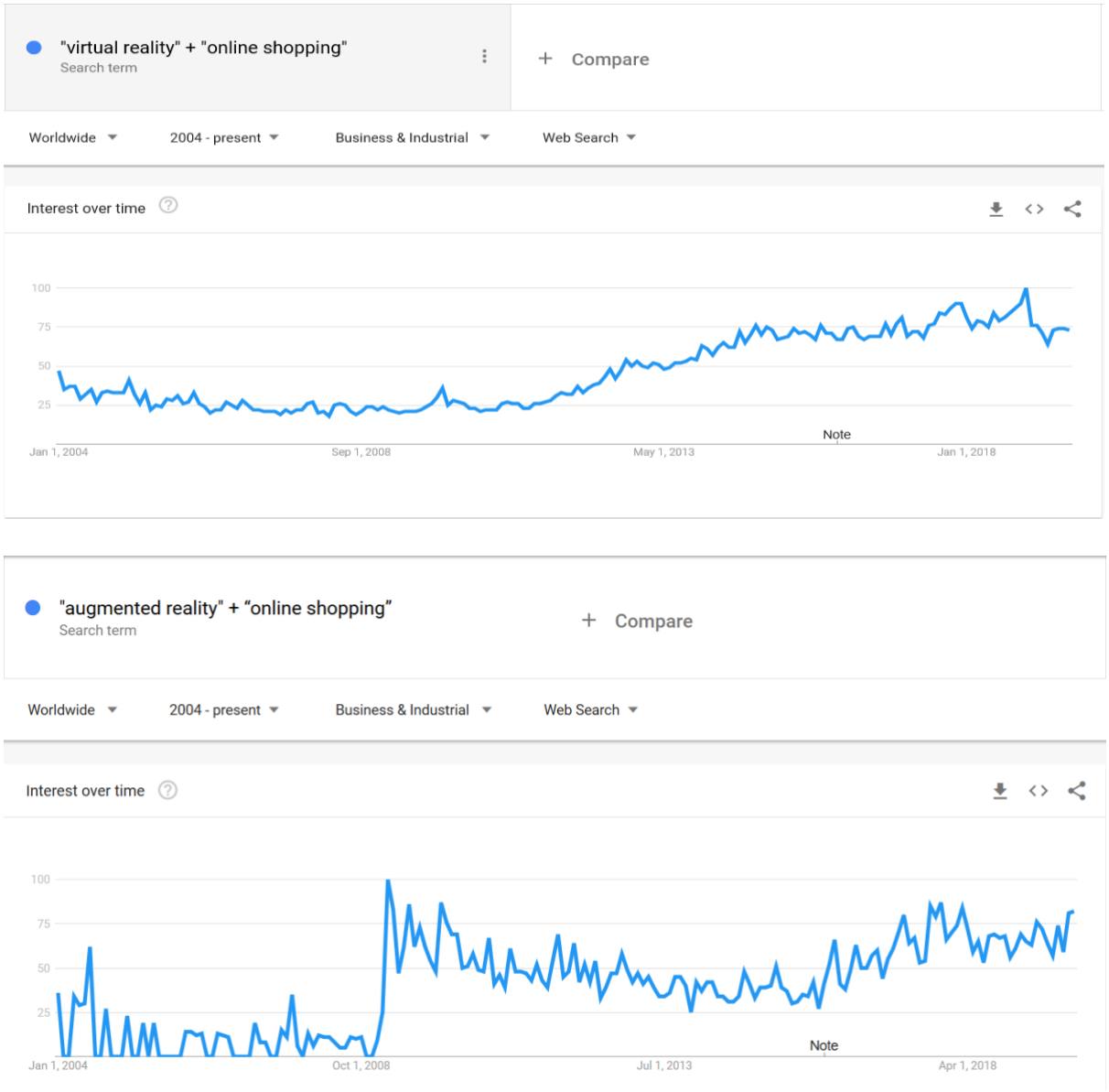

Figure 10: Google Trends results for keyword searches (as at 24 Aug, 2019)

While Balter and Finkelstein (2005) have shown that e-commerce can benefit from AR/VR technology through virtual 3D-modeling and real-time communication with other users, AR/VR technology has not been widely accepted by online retailers yet. Only recently have Amazon and Alibaba established their own AR/VR online retailing platforms: Amazon's AR View (Kleinman, 2018) and VR shopping kiosks (Horwitz, 2018), and Alibaba's Buy+ VR platform (Cao, 2017) (Tian, Yunwu, & Chao, 2017) provide immersive and interactive shopping experiences. Table 3 below presents some ways that AR/VR can be used to enhance online shopping.

Authors	Focus	Findings
Van & Poelman, 2007	AR for personal navigation: application, limitations, technical	AR has come a long way but still has some distance to go before the public accepts it as a familiar user interface
Funahashi et al. 2009	Simulation of touch	This study describes ways to simulate touching and feeling in virtual environments, which is useful for making virtual shopping more realistic.
Bamarouf & Smith, 2010	Haptic feedback glove	This glove provides a "touch-like" feeling in a virtual environment, enhancing the overall virtual reality experience.
Muta, Mukai et al. 2014.	A system to enable multiple people to shop together online	The Cyber Chamber system allows people to shop together virtually in groups and supports real-time chat. This could be a new social activity for families.
Zhang & Wong, 2014	Apparel fitting	Virtual fitting can be achieved by real-time, physical-based computer simulation with the help of machine learning. This technology helps online buyers choose clothes that fit them the best.
Altarteer et al. 2016	Product customization and visualization for luxury brands	Advances in hardware and software technologies enable better product visualization and customization to enhance the shopping experience, thus creating business value
Akiyama & Hsieh, 2018	Using customer shopping behavior data visualization and virtual reality to develop products	Visualizing customers' shopping behavior in real time helps optimize the online retailing experience. These researchers developed a visualization system that allows products to be rendered in real-time.
Chung et al. 2018	Use of different virtual reality device types for online shopping	The study examined if device types, such as head-mounted helmets or goggles, played a significant role in the quality of the online shopping experience.
Speicher et al. 2018	Immersive virtual-environments and 3D interaction for selling real estate	The metaphor of an apartment helps users to interact with the environment while viewing the apartment in a more efficient way. This will help the online real estate seller provide a better shopping experience.

Table 3: Future Possibilities of AR/VR

Table 3 lists future possibilities for using AR/VR in online retail. The contexts range from clothing (e.g. Zhang & Wong, 2014) to real estate (e.g. Speicher et al. 2018). Some of these possibilities are product-focused. For example, product visualization (Akiyama & Hsieh, 2018), haptic gloves (Bamarouf & Smith, 2010) and virtual apparel fitting (Zhang & Wong, 2014) aim to lower the perceived risk among e-commerce shoppers that the goods they purchase will be different from what they expected them to be. For example, customers using a pair of haptic gloves when shopping online receive electric pulses in their hand when they "feel" a product, allowing them to evaluate its patterns, weight, and textures. This means the shopping experience will be hugely enhanced, and become more

akin to the traditional online shopping domain. Virtual fitting provides real-time feedback to customers, allowing them to know if a piece of apparel looks good on them, allowing them to quickly decide if they should buy it or move on to the next one. Other researchers have investigated how AR/VR interacts with the process of navigating in an online store (e.g. Muta, Mukai et al. 2014), while others studied the hardware involved (e.g. Chung et al. 2018; Bamarouf & Smith, 2010). In later chapters, I will discuss how these possibilities have been implemented by other researchers, and how e-commerce will be influenced.

For the purposes of this dissertation, it is neither feasible nor necessary to go further into the technical aspects of AR/VR. Instead of studying AR/VR and e-commerce separately, the dissertation focuses on the impact that AR/VR will have on the online shopping domain. At the same time, the phrase "online shopping" is a broad concept. This dissertation will focus on shopping for tangible goods online: it is pointless to use AR/VR to sell intangible goods, such as video games or electronic books, as the experience of consuming these digital products has few physical aspects.

This section summarizes the potential benefits and downsides of using AR/VR.

Benefits: AR/VR technology allows the possibility that a fully virtual environment can be created, and it can be utilized in different ways, such as to make shopping more similar to entertainment (Sprout & Sprout, 2002). The fully immersive experience that AR/VR can provide will give users unique and innovative experiences. For retailers in industries like education and healthcare, AR/VR can provide many possibilities (Van & Poelman, 2007).

Challenges: When VR users mount a headset, they cannot see anything in the real environment, possibly leading to injuries or damage of the surroundings (Lovreglio et al., 2017). This is similar to AR users who move around while viewing their surroundings through their phones or tablets. Therefore, space limitations for using AR/VR turns out to be a key issue. The high price of the equipment is a challenge for most users, potentially preventing the people's acceptance of VR due to affordability (Lu et al., 2016). Another concern with VR is motion sickness, because the use of image sequences with a low refresh frequency could make people sick when they are watching animated images (Lindner et al., 2017). This issue can also be regarded as a hardware limitation as well, since good hardware can provide high-refresh-frequency images that can minimize the

motion sickness. Finally, creating a virtual environment is both expensive, technical-intense and time-consuming (Kanade et al., 1997).

Table *4*: Pros and Cons of AR/VR

4 lists the current advantages and disadvantages of AR/VR. These aspects of AR/VR can be related to the factors that influence the online shopping experience discussed earlier, and these relationships will be further explained in later paragraphs.

	User	**Retailer**
Advantages	Fully immersive and un-replaceable experience (Huber et al, 2018)	High compatibility makes AR/VR potentially capable of being used in many industries (Gillenson & Sherrell, 2002)
	Innovative ways to get trained or educated in virtual environment (Mujber et al., 2004)	Good choice for certain industries like medical, education or training etc. (Van & Poelman, 2007)
	Fully immersive in a virtual environment will provide a new way of fun (Sprout & Sprout, 2002)	Virtual environment allows content creators to create things that are impossible in a physical environment so as to avoid homogenized competition (Kung, Monroe, & Cox, 2002)
Disadvantages	Low affordability (Lu et al., 2016): equipment and setup is not cheap	Technical limitations like the high latency and low bandwidth of network connections, or the limited capability of hardware (Bastug et al., 2017)
	Too complex for normal users (Gillenson & Sherrell, 2002)	Early investment for the creation of virtual environment may requires lot of effort, in terms of money, technique and time (Kanade et al., 1997)
	Inconvenience when using AR/VR (Garro, et al., 2018)	
	Motion sickness (Lindner et al., 2017)	
	Users may get injured or damage their surroundings (Lovreglio t al., 2017).	

Table 4: Pros and Cons of AR/VR

Some of the disadvantages of AR/VR mentioned in Table 4 will most likely be eliminated as technology progresses. For example, the capability of AR/VR hardware will improve with innovations such as the introduction of 5nm CPU chips (Moore-Colyer, 2018). Similarly, the performance of AR/VR devices will improve with better network connections. For instance, 5G networks have lower latency than 4G networks, which will reduce the chances of users getting motion sickness and thus encouraging them to use the AR/VR devices for longer (Bastug et al., 2017; Sanders, 2019).

2.7 Limitations of AR/VR in online retailing

The combination of AR/VR and retail e-commerce is sometimes referred to as “virtual online shopping” (Ha &Lennon, 2010), or “new retail” (Bonetti et al., 2018). Bonetti et al., (2018) reviewed the literature and found that research on practical applications of AR/VR is still fragmented. While there is some research on the use of AR/VR in industries such as education and healthcare, little research has investigated how AR/VR will influence customer behaviors, the relationship between customers and retailers, and customers’ shopping experience.

Furthermore, much previous research on the impact of AR/VR in e-commerce focused on its technical capabilities. For example, Glazer and his colleagues (Glazer, Hobson, Deming, Royer, & Fehlhaber, 2011) simulated the interaction between a server and client website with VR features to find out the technical capabilities and limits of the immersive online experience. Cordier et al. (Cordier, Seo, & Magnenat-Thalmann, 2003) built an online store that allows customers to preview how clothes would be look like while try them on their own bodies, with the preview images being generated automatically after users input data about their proportions. Other researchers have studied the possibility of using augmented reality as a learning tool for school students: instead of replacing the real world with a wholly virtual environment, AR “adds on” some objects into the real world (Medicherla, Chang, & Morreale, 2010). An example of such an application is Construct3D (Kaufmann &Wagner, 2000).

This study will examine how the use of AR/VR influences online shopping, and why the number AR/VR applications has been limited. Possible barriers include the high initial costs of setting up a VR/AR platform, the need for skilled staff, and a lack of capacity of current networks to deliver high-quality video streams (Westphal, 2017). At the same time, general customer uncertainty or lack of awareness about the usefulness of AR/VR may also be restricting its utilization by retailers.

AR/VR technology may potential be able to overcome the limitations of online retailing by providing fully immersive, and overall a positive shopping experience. Shopping using AR/VR devices is a unique, experience irreplaceable experience. However, these devices are not very affordable, thus constraining the spread of AR/VR. This research project

focuses on the capabilities of AR/VR to discover new ways that may contribute to overcome the limits of traditional online shopping.

This chapter provides a good understanding of the key phenomenon, which is necessary before doing the systematic review. Key terms like AR/VR and E-commerce have been defined and explained and previous research on AR/VR and E-commerce has been discussed. Besides that, a summary of factors that influence the online shopping experience were summarized. In the next chapter, I will discuss the methodological guidelines that will be used for the study and how the data was collected.

Chapter 3: Methodology

This study is a review of the literature on the use of AR/VR in B2C e-commerce. Literature reviews can be carried out either qualitatively or quantitatively (using meta-analysis). This study uses a qualitative literature review, because the objective is not to understand the relationships among constructs, which is what meta-analyses are for, but to summarise the relationship between two technologies in a particular context. In this chapter, I will discuss the methodology I chose for the review and explain why it is appropriate for this study. In addition, the research context and ethical concerns will be mentioned. Finally, specific details of the data searching and collecting phase will be described.

3.1 Guidelines for Systematic Literature Reviews

This study will use a systematic literature review to answer its research question. Templier and Paré (2015) identified four types of literature reviews: “narrative review”, “cumulative review”, “aggregative review”, and “developmental review”. Narrative reviews summarize previously published research on a topic of interest and list relevant concepts, theories, research methods, or research outcomes. This type of literature review fits my research question because I am exploring the intersection of two different topics: AR/VR and e-commerce. Research in these two topics has been carried out from a variety of disciplines, such as computer science, human-computer interaction, marketing, and information systems. Therefore, a large variety of concepts and theories have been used to study the use of AR/VR in e-commerce. Before any cumulative or aggregative analysis can be made of the impact of AR/VR on e-commerce, researchers need a narrative review as a starting point to consolidate the different concepts and theories that have been used.

Since systematic reviews need to be objective, it is vital to follow guidelines that are explicit, rigorous and transparent (Greenhalgh et al. 2005). I will be following Greenhalgh et al.’s (2005) methodology and it involves these steps:

1. Planning phase:
    a) Choose methodology, analysis method and time period.
2. Searching phase:

a) Search for relevant non-academic reports to generate a quick overview of the overall topic
b) Formulate keywords
c) Search for academic research on the topic

3. Assessing phase:
   a) Ensure collected studies cover all aspects I need to cover in the research
   b) Examine key elements of the studies found in the previous phase, including their methodologies, contexts, and theoretical frameworks.
   c) To investigate how the findings can be presented, and to ensure data saturation (Ness & Fusch, 2015) for the research.
4. Analyzing and synthesizing phase:
   a) To synthesize the findings from the studies and analyze them using thematic analysis
   b) Discuss the findings and suggest possible directions for future researchers

3.2 Ethical Concerns

Since I will only use secondary data resources for the literature review, there are no ethical concerns that I will have to deal with. There will be no harm to participants. Obtaining informed consent from participants will also not be necessary, as well as putting in place measures to assure participants of their privacy.

3.3 Data Collection

Planning Phase

This review will cover studies published between 2008 and 2019. Although the concepts of AR and VR were proposed in the late 1980s, their development was constrained by the limited computational power and capabilities (Lindner et al., 2017). Thanks to Moore's law, technological improvements have meant that both AR/VR (Choi & Cheung, 2008; Venkataraman & Haftka, 2004) and online retail (Laudon & Traver, 2016) developed rapidly over the past decade. This has meant, for example, the introduction of higher-quality VR equipment with higher resolution images so that fewer VR users will experience motion sickness. Another example is the expansion of e-commerce to mobile devices and social media. I used Google Scholar and news reports as a starting point to get a brief understanding of the topic and to narrow down the search terms.

Searching phase

Based on my initial search on Google Scholar search, I shortlisted these keywords:

- “virtual reality” and “online shopping”, or “e-commerce” or “online retailing”
- “augmented reality” and “online shopping”, or “e-commerce” or “online retailing”

I then proceeded to use these keywords to search these academic databases: ACM Digital Library, EBSCO Host, ProQuest, JSTOR, Web of Science, ScienceDirect, and Wiley Online Library.

Assessing phase

This will be explained in the Findings chapter.

Analysis phase

To analyze my search results, I used thematic analysis, which is “a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set. Through focusing on meaning across a data set, thematic analysis allows the researcher to see and make sense of collective or shared meanings and experiences” (Braun & Clarke, 2012). Thematic analysis will be applied to the data that was collected to understand the overall pattern of knowledge in the field.

Chapter 4: Results

In this chapter, the key findings of my research will be presented. The first section summarizes the results of the search and filtering processes. Next, the second section lists the methods used to limit bias in this research. After that, I describe the influence of AR/VR on B2C e-commerce based on the results. Finally, I relate this relationship to the models of online shopping experience described in Chapter 2.

4.1 Database search results

The following table summarizes the results of my searches of each database for the different keyword combinations.

Database	Keywords	Number of articles found
ACM Digital Library	Virtual reality + E-commerce	14
	Virtual reality + Online shopping	10
	Virtual reality + Online retailing	0
	Augmented reality + E-commerce	7
	Augmented reality + Online shopping	7
	Augmented reality + Online retailing	0
EBSCO Host	Virtual reality + E-commerce	177
	Virtual reality + Online shopping	84
	Virtual reality + Online retailing	8
	Augmented reality + E-commerce	152
	Augmented reality + Online shopping	78
	Augmented reality + Online retailing	6
ProQuest	Virtual reality + E-commerce	793
	Virtual reality + Online shopping	464
	Virtual reality + Online retailing	64
	Augmented reality + E-commerce	265
	Augmented reality + Online shopping	171
	Augmented reality + Online retailing	18
JSTOR	Virtual reality + E-commerce	14
	Virtual reality + Online shopping	57
	Virtual reality + Online retailing	6
	Augmented reality + E-commerce	18
	Augmented reality + Online shopping	6
	Augmented reality + Online retailing	1
Web of Science	Virtual reality + E-commerce	50
	Virtual reality + Online shopping	18
	Virtual reality + Online retailing	4
	Augmented reality + E-commerce	46
	Augmented reality + Online shopping	25
	Augmented reality + Online retailing	4
ScienceDirect	Virtual reality + E-commerce	341
	Virtual reality + Online shopping	141
	Virtual reality + Online retailing	44
	Augmented reality + E-commerce	185

	Augmented reality + Online shopping	114
	Augmented reality + Online retailing	32
Wiley Online Library	Virtual reality + Ecommerce	218
	Virtual reality + Online shopping	65
	Virtual reality + Online retailing	13
	Augmented reality + E-commerce	116
	Augmented reality + Online shopping	36
	Augmented reality + Online retailing	6

Table 5: Database Search Results

We can observe a pattern matching the Google Trends results depicted in Figure 10: while virtual reality and augmented reality are popular topics for research, relatively little can be found on their use or adoption for online retail. Table 5 also shows that, in all of the databases except Web of Science, there were fewer AR-related articles compared to VR-related articles. It is worth noting that AR-related articles always mention VR because the two technologies are connected, as seen in Figure 7 (the Virtuality Continuum). Many articles, up to 80% of the results from EBSCO Host, were about the application of AR/VR in various contexts, such as medical science, education, and job training, while the remaining 20% were pure technical studies. There were a few articles on the use of AR/VR for e-commerce in emerging markets, such as Xu (2018).

Assessing Phase

In total, more than 3,000 articles were found from the keyword search. This was too high a number for a review, so I screened them for relevance. I kept all the articles from the databases that had fewer than 200 results. For databases that had more than 200 results (articles), I ranked the results from each database by relevance, and chose only 200 from each database. This process led to a list of 769 articles.

The 769 articles were reviewed for their fit with the study's objectives. Figure 11 below shows the process that was followed and how the corpus of articles was narrowed down. After removing duplicate articles in Step 2, 628 articles remained. Next, I quickly scanned each article to check if it was related to my research, or whether the search process had picked it up because it coincidentally matched the keywords I searched for. After culling more than 400 articles, what remained were 159 articles. These were then read carefully to identify articles that were purely technically-focused and those that were very similar. Examples of articles that were removed from the review because of a lack of relevance included those that discussed AR/VR peripherally (e.g. the articles were about the design or

content of online shopping websites, or on activities that used VR such as garment design), or those that described the technical aspects of AR/VR, such as algorithms, or its working principles. In addition, some topics were very popular, such as those that discussed the influence of the user interface and customer service on consumer behavior. Since they were similar to each other, I kept only one or two articles on each of these topics for my review. After these assessment processes, 19 articles remained.

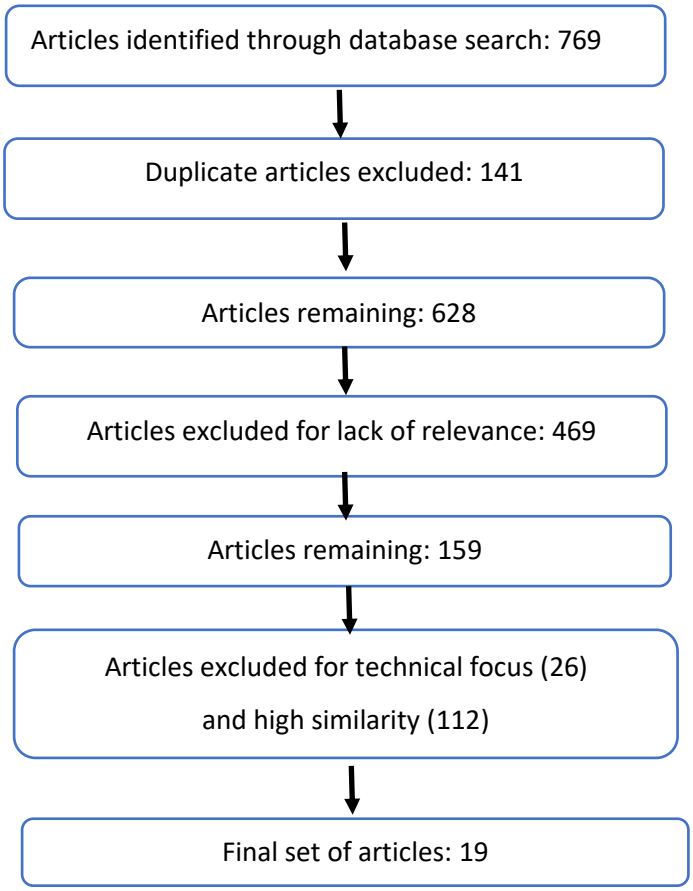

Figure 11: Flow chart

4.2 Analysis of final set of articles

The review revealed that AR/VR has been applied in many industries; this multi-sector compatibility reveals that AR/VR technology has a wide range of possibilities. The table below lists the industries where AR/VR has been used according to the articles reviewed. Some articles covered multiple industries; for instance, Tian et al (2017) studied the education, medical and online shopping industries. Nearly half of the articles looked at business-related AR/VR applications.

Industry	Number
Educational	10
Medical	12
Training	5
Business	47
Other (museum displays, gaming etc.)	37

Table 6: Industries where AR/VR has been or can be applied

Appendix lists the articles that were found and their important characteristics. Methodologically, many studies used experiments. I categorized their main findings following the constructs identified in the models of online shopping experience explained earlier in Section 2.3. Table 7 below summarizes how researchers believe AR/VR will influence the online shopping experience. The use of AR/VR can either enhance customers' OSE positively or eliminate those factors that have a negative impact on customers' OSE.

	Factors that Enhance the Online Shopping Experience	Impact on the Online Shopping Experience
Factors that are directly affected by the use of AR/VR		
	Website design	AR/VR can help build a fully immersive interface (Huber et al, 2018)
	Service quality	AR/VR can help online sellers provide better quality service; instead of simply using text to chat with a consumer, they could use a virtual character that has body motions or even facial expressions (Akiyama & Hsieh, 2018). This could make communication-sensitive consumers happier with their shopping experience
	Convenience	AR/VR may will make user activities more intuitive, and therefore more user-friendly. One example is to use haptic gloves (Bamarouf & Smith, 2010). This glove allows users to "feel" a virtual product through electric pulses.
	Entertainment	Full immersion in a virtual environment will provide a new way of fun (Sprout & Sprout, 2002). Augmented reality allows virtual objects to be put into real surroundings, which can also be appealing.
	Interactivity	Better interactivity, which includes improved convenience, communication, and customer service (Chen & Chang, 2003), enhance performance (Sprout & Sprout, 2002). Customer service staff will have more options to interact with customers. This increase in options may potentially satisfy more customers.

	Additional Source of Information about Products	AR/VR can allow users check items from different angles, providing more realistic sense of feeling for the goods, instead of relying on the sellers' images. One example is apparel (Zhang and Wong, 2014). Customers may find problems about a product from different angles, and AR/VR allows them to do that. This helps them make a better-considered decision.
	After-sale service	AR/VR will provide a good way to improve customer service; for example, consumers who have questions regarding how to use a good can be showed how to do so using VR. Customer service staff can demonstrate how to use an item, instead of customers having to read through a long instruction guide.
	Previsualization	Previsualization will do a great job in areas like virtual fitting and 3D-modeling (Magnenat-Thalmann et al., 2011). People may have a good experience as see the previsualized result.
Factors that are INDIRECTLY affected by AR/VR, which in turn enhances the online shopping experience		
	Aesthetics	Since aesthetics are a highly subjective concept (Mosteller et al., 2014), it will be difficult for AR/VR to directly enhance it. However, it provides more possibilities and choices for retailers to showcase and demonstrate their products.
	Technological developments	Technical advances, such as more capable hardware (Lindner et al., 2017), more optimized software algorithms, or cloud computing (Bastug et al., 2017), will indirectly benefit AR/VR.
	Accessibility	Online stores with AR/VR features may stand out from their competitors when consumers with disabilities find them through searches for "AR/VR" services. In this case, AR/VR provide more options for customers as it is a unique feature for an online store.
Factors that are NOT related to the use of AR/VR		
	Delivery	AR/VR has no relation to delivery issues.
	Connection Quality	Network connections are not affected by the use of AR/VR

Table 7: Relationship of AR/VR and factors that influence OSE

As can be seen, there are multiple ways to improve those factors that influence consumers' online shopping experience. The table below shows what I found in my study.

	Factors enhanced by AR/VR that <u>directly</u> influence the online shopping experience	**Factors enhanced by AR/VR that <u>indirectly</u> influence the online shopping experience**	**Research on AR/VR that is NOT related to online shopping**
Technical Issues	Service quality (Akiyama & Hsieh, 2018)	Accessibility (Swapana & Padmavathy, 2017)	
	Interactivity (Chen & Chang, 2003; Lécuyer et al. 2008; Sprout & Sprout, 2002)		
	Pre-purchase product visualization (Altarteer et al. 2016; Magnenat -Thalmann et al., 2011; Yang & Xiong, 2019)		
	Product diversity (Kung, Monroe, & Cox, 2002)		

User experience Issues	Additional source of information about products (Zhang and Wong, 2014)	Aesthetics (Mosteller et al., 2014)	Urban delivery (Patier et al., 2014)
	Supports shopping in groups (Muta et al. 2014)	Expectations gap between AR/VR experience and product (Farah et al. 2019)	
	Entertainment (Sprout & Sprout, 2002)	Affect (Chung et al. 2018; Izogo & Jayawardhena, 2018)	
	Website/interface design (Bonetti et al. 2018; Huber et al, 2018; Xin et al. 2017)		
	Convenience (Bamarouf & Smith, 2010; Funahashi et al. 2009; Speicher et al. 2018)		
	Motion sickness (Lindner et al., 2017)		

Table 8: Results of Literature Review

In this chapter, an overview of the findings was given. This material will be discussed in the final chapter.

Chapter 5: Discussion & Conclusion

In the discussion and conclusion chapter, an overall discussion based on the findings will be presented, as well as possible directions for future researchers.

5.1 Discussion

AR/VR is a general-purpose technology that creates a virtual environment that allows users to have fully immersive experiences. The earlier chapters have described how previous researchers have investigated many aspects of AR/VR, especially its technical aspects and its application in various contexts. AR/VR has been gradually accepted and used in many domains such as entertainment, education and training, and healthcare.

In the online retailing domain, AR/VR can be used to impact various factors that influence consumers' online shopping experience. Consumers' online shopping experience (OSE) has been identified as the key driver of their purchasing preferences and satisfaction levels (Khalifa & Liu, 2007). OSE is affected by many factors, for instance, delivery issues, service quality, interface design, and connection quality. For example, convenience is one of the important factors that influence people's OSE. AR/VR can make online shopping more user-friendly and convenient by enabling consumers to use avatars in virtual shopping environments that they can control to support features such as virtual fitting (Zhang & Wong, 2014). AR/VR can also improve service quality by enabling stores to "see" the different items buyers are browsing and offer suggestions (Akiyama & Hsieh, 2018).

AR/VR's ability to provide a highly immersive virtual environment can eliminate technical boundaries which limit consumers' enjoyment of online shopping. Currently, most online shopping takes place through a personal computer or a smartphone/mobile device. Using these platforms means that the online shopping experience is limited by their technology capabilities, such as two-dimensional (2D) displays. These constraints make online shopping less convenient, potentially reducing the use and acceptance of online shopping in society. Therefore, there is space for improving the experience for online shopping users via the application of AR/VR, especially when combined with other technologies, such as haptic gloves (Bamarouf & Smith, 2010) that provide feedback on the weight and texture of products to consumers, or gamification (Meegahapola & Perera, 2017). In terms of the aesthetics of online retail, AR/VR enables retailers to display their goods in a radically

different manner from a typical online store, so that they can attract consumers who are more comfortable in traditional retail shops. Besides pure AR/VR, some online retailers, such as Alibaba (Cao, 2017; Tian, Yunwu, & Chao, 2017), are using mixed reality, which combines real scenes with virtual elements. Mixed reality shopping is attractive to retailers because the cost of creating mixed reality scenes is much lower than pure AR/VR contexts and is also more affordable for the general public. While technical obstacles have prevented AR/VR from spreading widely in the online shopping industry, these obstacles should be gradually eliminated as technology improves.

However, while AR/VR provides possibilities that may increase the overall satisfaction of consumers who shop online, certain risks also exist. For example, individuals may injure themselves when they are using a virtual helmet if they are not careful (Lovreglio t al., 2017), or experience motion sickness. Another issue is that the costs of the equipment needed (such as goggles and headsets) may be too high, making AR/VR unaffordable for many people. If there is low acceptance of AR/VR among consumers, online retailers may not realise enough returns from their investment into virtual shopping.

5.2 Future Research

There are several possible research directions for future researchers.

First, further research is needed on the technical aspects of AR/VR, such as new generations of processors, new algorithms or software for optimizing performance, and new network technology, such as 5G which will support faster and more stable data transfers. Researchers should especially focus on developing lower-cost AR/VR technologies to increase customer adoption. Current AR/VR performance is constrained by the computational power of CPUs and GPUs, so one approach would be to explore the use of cloud computing, which would move the resource-intensive computation aspects of AR/VR to remote servers, instead of the local device.

Second, researchers should study how AR/VR can contribute to improving other aspects of the online shopping experience that have been overlooked so far. One example is a “cyber chamber” (Muta et al., 2014) to allow multiple people to shop together in the same virtual environment, supporting real-time voice chatting so that individuals can comment on the same virtual object simultaneously. This new system allows a “virtual social behavior” to

take place without leaving one's premises and may perhaps become a popular social or family activity in the future. A second example is to develop other ways to help users achieve physically tangible interactions, such as the haptic feedback glove (Bamarouf & Smith, 2010). This will again remove one current negative aspect of online shopping.

The misalignment of images and products has always been an issue in online shopping for customers (Gilbride, 2016). Customers are not able to know the details of a product after viewing a few images of it online, making it possible that customers will receive a product that is differs from what they saw online. This affects their trust in online retailers, and negatively influences their online shopping experience. Therefore, researchers could also examine how AR/VR implementations could be used to build trust between online sellers and buyers. For instance, a human-like virtual avatar representing the seller in a virtual environment may possibly enhance a customer's trust level in a particular seller or store (Nassiri, 2008).

Another area for future researchers is to improve the quality of interaction in virtual environments. AR/VR users may suffer from motion sickness or at the least be confused by the relatively less user-friendly interface compared to other consumer devices. Research on brain-computer-interaction may help improve the complex interaction in virtual environments. There is also a need to collect and analyze data to calculate how AR/VR technology is improving different aspects of the online shopping experience and overall customer satisfaction. This information will help marketers better target potential adopters and develop appropriate marketing strategies.

Lastly, customers with certain physical disabilities may require specially designed equipment to enjoy online shopping since they are unable to move their bodies in line with the requirements of current AR/VR gear. One suggestion would be to develop a new type of wheelchair that is compatible with AR/VR gear. This would enable physically disabled people to "travel" via AR/VR and experience activities such as visiting museums far from where they are located (Schofield et al., 2018). Blind individuals could possibly use special-made helmets which support brain-computer interaction technology to take part in online shopping.

5.3 Limitations

A systematic literature review has certain limitations. First, the keywords used to collect data may restrict the studies that were found. Since I did not focus on the technical aspects of AR/VR and E-commerce, there could be some relevant studies that I may have missed.

Second, the data that was found was manually filtered. Thus, it is possible that some important material could have been missed. Third, there is a trilemma for individual researchers, who must balance between quality, difficulty and the investment required for the research project. Finally, since AR/VR technology is developing fast, some of the conclusions of the researchers whom I cite in this study may already be out of date or will be soon. Therefore, the findings and conclusions of this research could possibly go out of date soon as well.

A point to note that it is possible that the attitude of researchers towards AR/VR's combination with e-commerce may bias their research. To uncover researchers' attitudes towards the topic, it is vital to understand the meaning of the articles that I found. Following Michael's (2018) concept of a "meaning unit", I coded the type of words used in some articles to describe AR/VR. Different words with identical or similar meanings will be coded under one category. For example, articles with words such as "good" or "futuristic" will be considered to have a positive view of AR/VR, while others may be considered to have a neutral view or a negative view. After that, I counted the frequency of all tags representing different views of AR/VR. Table 8 summarizes the views of some researchers on AR/VR's application in e-commerce, both from its technical feasibility and the business case. The table shows a diversity of opinions, although they are mostly positive. Future reviews on this topic should thus consider incorporating attitude into their analysis.

Report/News data	**Attitude/Opinion (Meaning Unit)**
Positive	
Horwitz, 2018	futuristic, nice, ingenious
Carlton, 2018	futuristic, easy to use, perfectly, big budget, idealized fusion, clean, reinvigorate, fun interactive boost, new direction, unlimited
Master, 2019	strongly growing, no signs of decline, boosted e-commerce sales, nearly doubled in only one year, confidence, significant number of potential customers
Yang & Xiong, 2019	revolutionary, enhance customer satisfaction, attracted attention, sizeable positive effect
Chattaraman et al., 2012	Benefits, important implications, experimental design, trust
Wu et al., 2014	attracted a lot of attention, great potential, signification implications, positive influence, new insights

Neutral/Balanced	
Ben, 2017	Potential barriers to success, poor experience, limited usability, damaging business reputation, fastest growing, never before
Yim et al., 2017	hard time positioning, complaints- slow response, unrealistic computer graphic, a lot of room for AR to improve, strongly encouraged for future researchers
Negative	
Cody, 2018	Do not know its long-term effects on body or mind, negative side effects, digital motion sickness, sensory conflict

Table 9: Selected Examples of Attitudes of Researchers

5.4 Conclusion

This study reviewed the role of augmented reality and virtual reality (VR) in online retailing. After explaining the working principles and chronological history of AR/VR and e-commerce, I identified the factors that influenced online shopping experience. I then examined research on how AR/VR and online retailing can be combined. AR/VR has already been implemented in various domains, like training, education, and property sales, indicating that it is possible that AR/VR can be more widely used for online retailing. Some of AR/VR's features can directly improve certain predictors of consumers' online shopping experience, but not all of them. At the same time, AR/VR technology carries certain risks that need to be mitigated.

AR/VR is starting to be used in e-commerce but still has a long way to go. In general, many researchers hold a positive attitude for AR/VR's application in the future in the business world because of its unique features. However, this enthusiasm is dampened by concerns such as affordability, technical obstacles, or convenience.

References

Akiyama, G., & Hsieh, R. (2018). Karte Garden. *In Proceedings of the Virtual Reality International Conference-Laval Virtual* (p. 24). ACM.

Alshehri, M., & Drew, S. (2010). Implementation of e-Government: Advantages and Challenges. In *International Association for Scientific Knowledge (IASK)*.

Altarteer, S., Vassilis, C., Harrison, D., & Chan, W. (2016). Product Customisation: Virtual Reality and New Opportunities for Luxury Brands Online Trading. *presented at the meeting of the Proceedings of the 21st International Conference on Web3D Technology, Anaheim, California*.

Anand, A., & Kulshreshtha, S. (2007). The B2C Adoption in Retail Firms in India. In *Second International Conference on Systems (ICONS'07)* (pp. 46-46). IEEE.

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. *IEEE Computer Graphics and Applications, 21*(6), 34-47.

Balter, C., & Finkelstein, B. (2005). Online Shopping with Virtual Modeling and Peer Review. *U.S. Patent No. 6,901,379*. Washington, DC: U.S. Patent and Trademark Office.

Bamarouf, Y. A., & Smith, S. P. (2010). Evaluating Virtual Weights for Haptically Enabled Online Shopping. *Presented at the meeting of the Proceedings of the 17th ACM Symposium on Virtual Reality Software and Technology, Hong Kong*.

Basdogan, C., Sedef, M., Harders, M., & Wesarg, S. (2007). VR-based Simulators for Training in Minimally Invasive Surgery. *IEEE Computer Graphics and Applications*, 27(2), 54-66.

Bastug, E., Bennis, M., Médard, M., & Debbah, M. (2017). Toward interconnected Virtual Reality: Opportunities, Challenges, and Enablers. *IEEE Communications Magazine*, *55*(6), 110-117.

Berryman, D. R. (2012). Augmented Reality: A Review. *Medical Reference Services Quarterly*, *31*(2), 212-218.

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive Virtual Environment Technology as A Methodological Tool for Social Psychology. *Psychological Inquiry*, 13(2), 103-124.

Block, B., & McNally, P. (2013). 3D Storytelling: How Stereoscopic 3D Works and How to use it. *Taylor & Francis*

Braun, V., & Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, 3(2), 77-101.

Bowman, D. A., & McMahan, R. P. (2007). Virtual Reality: How Much Immersion is Enough? *Computer, 40(7), 36-43.*

Bonetti, F., Warnaby, G., & Quinn, L. (2018). Augmented Reality and Virtual Reality in Physical and Online Retailing: A review, Synthesis and Research Agenda. In *Augmented Reality and Virtual Reality* (pp. 119-132). Springer, Cham

Cao, B. (2017) Alibaba's VR Shopping: Fad or Future? Retrieved from *https://digit.hbs.org/submission/alibabas-vr-shopping-fad-or-future/* (June 4 2019)

Carlton, B. (2018). "Alibaba Is Using AR To Change The Shopping Experience." Retrieved from https://vrscout.com/news/alibaba-ar-shopping-experience/

Carrozzino, M., & Bergamasco, M. (2010). Beyond Virtual Museums: Experiencing Immersive Virtual Reality in Real Museums. *Journal of Cultural Heritage*, *11*(4), 452-458.

Caudell, T. P., & Mizell, D. W. (1992). Augmented Reality: An Application of Heads-Up Display Technology to Manual Manufacturing Processes. In *Proceedings of the Twenty-fifth Hawaii International Conference on System Sciences* (Vol. 2, pp. 659-669). IEEE.

Chattaraman, V., Kwon, W.-S., & Gilbert, J. E. (2012). Virtual Agents in Retail Web Sites: Benefits of Simulated Social Interaction for Older Users. *Computers in Human Behavior, 28(6)*, 2055-2066.

Chatterjee, D., Grewal, R., & Sambamurthy, V. (2002). Shaping up for E-Commerce: Institutional Enablers of the Organizational Assimilation of Web Technologies. *MIS Quarterly*, 65-89.

Chen, S. J., & Chang, T. Z. (2003). A Descriptive Model of Online Shopping Process: some Empirical Results. *International Journal of Service Industry Management*, *14*(5), 556-569.

Choi, S. H., & Cheung, H. H. (2008). A Versatile Virtual Prototyping System for Rapid Product Development. *Computers in Industry*, *59*(5), 477-488.

Chung, S., Kramer, T., & Wong, E. M. (2018). Do Touch Interface Users Feel More Engaged? The Impact of Input Device Type on Online Shoppers' Engagement, Affect, and Purchase Decisions. *Psychology & Marketing, 35*(11), 795-806. https://doi.org/10.1002/mar.21135

Cordier, F., Seo, H., & Magnenat-Thalmann, N. (2003). Made-to-Measure Technologies for an Online Clothing Store. *IEEE Computer Graphics and Applications, 23*(1), 38-48.

de la Peña, N., Weil, P., Llobera, J., Giannopoulos, E., Pomés, A., Spanlang, B., ... & Slater, M. (2010). Immersive journalism: immersive virtual reality for the first-person experience of news. *Presence: Teleoperators and virtual environments*, *19*(4), 291-301.

Derek, E. (2017). Augmented Reality Apps for Education. *Virtual Reality Pop.* Retrieved from https://virtualrealitypop.com/aredu-educational-augmented-reality-apps-5e6599529807

Ding, F., Huo, J., & Campos, J. K. (2017). The Development of Cross Border E-commerce. In *International Conference on Transformations and Innovations in Management (ICTIM 2017)*. Atlantis Press

Disztinger, P., Schlögl, S., & Groth, A. (2017). Technology Acceptance of Virtual Reality for Travel Planning. In: Schegg R., Stangl B. (eds) *Information and Communication Technologies in Tourism 2017*. Springer, Cham

Farah, M. F., Ramadan, Z. B., & Harb, D. H. (2019). The examination of virtual reality at the intersection of consumer experience, shopping journey and physical retailing. *Journal of Retailing and Consumer Services*, *48*, 136-143.

Funahashi, K., Ichino, M., & Teshigahara, M. (2009). Experiments for Developing Touchable Online Shopping System*. presented at the meeting of the Proceedings of the 16th ACM Symposium on Virtual Reality Software and Technology, Kyoto, Japan*. Retrieved from https://doi.org/10.1145/1643928.1643985

Garro, A., Mühlhäuser, M., Tundis, A., Baldoni, M., Baroglio, C., Bergenti, F., & Torroni, P. (2018). Intelligent Agents: Multi-Agent Systems. *Encyclopedia of Bioinformatics and Computational Biology: ABC of Bioinformatics*, 315.

Gilbride, T. J., Currim, I. S., Mintz, O., & Siddarth, S. (2016). A Model for Inferring Market Preferences from Online Retail Product Information Matrices. *Journal of Retailing, 92*(4), 470-485.

Gillenson, M. L., & Sherrell, D. L. (2002). Enticing Online Consumers: An Extended Technology Acceptance Perspective. *Information & Management*, *39*(8), 705-719.

Glazer, E., Hobson, C. L., Deming, E. S., Royer, C., & Fehlhaber, J. S. (2011). U.S. Patent No. 8,069,095. Method and Apparatus for a User to Shop Online in A Three-Dimensional Virtual Reality Setting*. Washington, DC: U.S. Patent and Trademark Office*.

Graphics, S. (2018). "How to Make an Anaglyph 3D Image in Photoshop That Really Works!". Retrieved from https://www.youtube.com/watch?v=C50IRg_ZE7o.

Greenbaum, P. (1992). The Lawnmower Man. *Film and video*, *9*(3), 58-62

Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., Kyriakidou, O., & Peacock, R. (2005). Storylines of Research in Diffusion of Innovation: A Meta-Narrative Approach to Systematic Review. *Social Science & Medicine, 61(2),* 417-430.

Grönlund, Å., & Horan, T. A. (2005). Introducing E-Gov: History, Definitions, and Issues. *Communications of the Association for Information Systems*, *15*(1), 39

Ha, Y., & Lennon, S. J. (2010). Online Visual Merchandising (VMD) Cues and Consumer Pleasure and Arousal: Purchasing Versus Browsing Situation. *Psychology & Marketing*, *27*(2), 141-165

Hawkins, D. G. (1995). Virtual Reality and Passive Simulators: The Future of Fun. *Communication in the Age of Virtual Reality*, 159-189.

Horwitz, J. (2018) Watch Amazon's VR Kiosks Transform the Future of Shopping. *Retrieved from https://venturebeat.com/2018/07/12/watch-amazons-vr-kiosks-transform-the-future-of-shopping/* (June 4 2019)

Huang, Z., & Benyoucef, M. (2013). From E-commerce to Social Commerce: A Close Look at Design Features. *Electronic Commerce Research and Applications*, *12*(4), 246-259.

Huang, Y., Liu, Y., & Wang, Y. (2009, October). AR-View: An Augmented Reality Device for Digital Reconstruction of Yuangmingyuan. In 2009 *IEEE International Symposium on Mixed and Augmented Reality-Arts, Media and Humanities (pp. 3-7).*

Huber, F., Hohlbaum, M. F., Baumann, T. C., & Schürmann, K. (2018). Digital and Social Marketing: Virtual Reality: Online Shopping with Virtual Reality Versus 2D Display:

The Mediating Role of Sense of Presence on Pleasure and Perceived Product Risk. *AMA Summer Educators' Conference Proceedings*, 29, DS-52-DS-53.

Iankova, S., Davies, I., Archer-Brown, C., Marder, B., & Yau, A. (2018). A Comparison of Social Media Marketing between B2B, B2C and Mixed Business Models. *Industrial Marketing Management*, *81*, 169-179.

Izogo, E. E., & Jayawardhena, C. (2018). Online Shopping Experience in an Emerging E-Retailing Market: Towards a Conceptual Model. *Journal of Consumer Behaviour*, *17*(4), 379-392. https://doi.org/10.1002/cb.1715

Jayaram, S., Connacher, H. I., & Lyons, K. W. (1997). Virtual Assembly using Virtual Reality Techniques. *Computer-Aided Design, 29*(8), 575-584.

Kanade, T., Rander, P., & Narayanan, P. J. (1997). Virtualized Reality: Constructing Virtual Worlds from Real Scenes. *IEEE multimedia*, *4*(1), 34-47.

Kaufmann, H., Schmalstieg, D., & Wagner, M. (2000). Construct3D: A Virtual Reality Application for Mathematics and Geometry Education. *Education and Information Technologies*, *5*(4), 263-276.

Khalifa, M., & Liu, V. (2007). Online Consumer Retention: Contingent Effects of Online Shopping Habit and Online Shopping Experience. *European Journal of Information Systems*, *16*(6), 780-792.

Kleinman, J. (2018) How to Use the Amazon App's AR Shopping Feature. Retrieved from https://lifehacker.com/how-to-use-the-amazon-apps-ar-shopping-feature-1823362595 (June 4 2019).

Kraemer, K. L., & Dedrick, J. (2002). Strategic Use of the Internet and E-commerce: Cisco Systems. *The Journal of Strategic Information Systems*, *11*(1), 5-29.

Kung, M., Monroe, K. B., & Cox, J. L. (2002). Pricing on the Internet. *Journal of Product & Brand Management, 11(5)*, 274-288.

Traver, C. G., & Laudon, K. C. (2008). E-commerce: Business, Technology, Society. *Pearson Prentice Hall/Pearson Education*.

Lackermair, G. (2011). Hybrid cloud architectures for the online commerce. *Procedia Computer Science, 3*, 550-555.

Lindner, P., Miloff, A., Hamilton, W., Reuterskiöld, L., Andersson, G., Powers, M. B., & Carlbring, P. (2017). Creating State of the Art, Next-Generation Virtual Reality Exposure Therapies for Anxiety Disorders Using Consumer Hardware Platforms: Design Considerations and Future Directions. *Cognitive Behaviour Therapy*, *46*(5), 404-420.

Lécuyer, A., Lotte, F., Reilly, R. B., Leeb, R., Hirose, M., & Slater, M. (2008). Brain-Computer Interfaces, Virtual Reality, and Videogames. *Computer*, *41*(10), 66-72.

Lee, G. G., & Lin, H. F. (2005). Customer Perceptions of E-Service Quality in Online Shopping. *International Journal of Retail & Distribution Management*, *33*(2), 161-176.

Lovreglio, R., Gonzalez, V., Amor, R., Spearpoint, M., Thomas, J., Trotter, M., & Sacks, R. (2017). The Need for Enhancing Earthquake Evacuee Safety by Using Virtual Reality Serious Games. In *Lean & Computing in Construction Congress* (pp. 1-9).

Lu, A., Huang, J., Zhang, S., Wang, C., & Wang, W. (2016). Towards Mobile Immersive Analysis: A Study of Applications. In *2016 Workshop on Immersive Analytics (IA)* (pp. 25-30). IEEE.

Lv, Z., Jin, Y., & Huang, J. (2018). How Do Sellers use Live Chat to Influence Consumer Purchase Decisions in China?. *Electronic Commerce Research and Applications*, *28*, 102-113.

Leston, J. (1996). Virtual Reality: the IT Perspective. *IT NOW, 38*(3), 12-13.

Magnenat-Thalmann, N., Kevelham, B., Volino, P., Kasap, M., & Lyard, E. (2011). 3D web-based virtual try on of physically simulated clothes. *Computer-Aided Design and Applications*, *8*(2), 163-174.

Mahatanankoon, P., Wen, H. J., & Lim, B. (2005). Consumer-based M-commerce: Exploring Consumer Perception of Mobile Applications. *Computer Standards & Interfaces*, *27*(4), 347-357.

Mäkeläinen, S. I. (2006). From B2C to C2C E-commerce. *Course Essay: Department of Computer Science, University of Helsinki.*

Mallapragada, G., Chandukala, S. R., & Liu, Q. (2016). Exploring the Effects of "What" (product) and "Where" (website) Characteristics on Online Shopping Behavior. *Journal of Marketing*, *80*(2), 21-38.

Master, N. (2019). "*Online Shopping Trends 2019 & Key Figures - What You Need to Know.*" Retrieved from https://www.nationmaster.com/ecommerce

McMahan, R. P., Bowman, D. A., Zielinski, D. J., & Brady, R. B. (2012). Evaluating Display Fidelity and Interaction Fidelity in A Virtual Reality Game. *IEEE Transactions on Visualization and Computer Graphics, 18(4)*, 626-633.

Michael, J. (2018). Data Analysis Methods for Qualitative Research: Managing the Challenges of Coding, Interrater Reliability, and Thematic Analysis. *The Qualitative Report 23(11):* 2622-2633.

Meegahapola, L., & Perera, I. (2017). Enhanced in-store shopping experience through smart phone based mixed reality application. In *2017 Seventeenth International Conference on Advances in ICT for Emerging Regions (ICTer)* (pp. 1-8). IEEE.

Milgram, P., & Kishino, F. (1994). A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on Information and Systems*, 77(12), 1321-1329.

Moore-Colyer, R. (2018). Apple reportedly working on a VR/AR headset with dual 8K display. *The Inquirer*, 30 April. Retrieved from https://www.theinquirer.net/inquirer/news/3031298/apple-supposedly-working-on-vr-and-ar-headset-with-8k-displays-and-a-2020-launch

Mosteller, J., Donthu, N., & Eroglu, S. (2014). The Fluent Online Shopping Experience. *Journal of Business Research, 67*(11), 2486-2493.

Mujber, T. S., Szecsi, T., & Hashmi, M. S. (2004). Virtual Reality Applications in Manufacturing Process Simulation. *Journal of Materials Processing Technology*, *155*, 1834-1838.

Muta, M., Mukai, K., Toumoto, R., Okuzono, M., Hoshino, J., Hirano, H., & Masuko, S. (2014, November). Cyber Chamber: Multi-user Collaborative Assistance System for Online Shopping. In *Proceedings of the Ninth ACM International Conference on Interactive Tabletops and Surfaces* (pp. 289-294). ACM.

Nassiri, N. (2008, March). Increasing Trust Through the Use of 3D E-commerce Environment. In *Proceedings of the 2008 ACM Symposium on Applied Computing* (pp. 1463-1466).

Nieckarz Jr, P. P. (2005). Community in Cyber Space?: The Role of the Internet in Facilitating and Maintaining A Community of Live Music Collecting and Trading. *City & Community*, *4*(4), 403-423.

Nguyen, D. H., de Leeuw, S., & Dullaert, W. E. (2018). Consumer Behaviour and Order Fulfilment in Online Retailing: A Systematic Review. *International Journal of Management Reviews, 20(2)*, 255-276.

Ohta, Y., & Tamura, H. (2014). *Mixed Reality: Merging Real and Virtual Worlds*. Springer.

Ordanini, A., & Pol, A. (2001). Infomediation and Competitive Advantage in B2B Digital Marketplaces. *European Management Journal*, *19*(3), 276-285.

Orendorff, A. (2019). "Global Ecommerce Statistics and Trends to Launch Your Business Beyond Borders." *Global Ecommerce*. Retrieved from https://www.shopify.com/enterprise/global-ecommerce-statistics

Patier, D., David, B., Chalon, R., & Deslandres, V. (2014). A New Concept for Urban Logistics Delivery Area Booking. *Procedia-Social and Behavioral Sciences*, *125*, 99-110.

Quan, T. W., & Williams, K. R. (2018). Product Variety, Across-market Demand Heterogeneity, and the Value of Online Retail. *The RAND Journal of Economics, 49(4)*, 877-913.

Rask, M., & Dholakia, N. (2001). Next to the Customer's Heart and Wallet: Frameworks for Exploring the Emerging M-commerce Arena. *Working Paper*, *Aalborg University, Centre for International Studies.* Retrieved from https://www.researchgate.net/profile/Morten_Rask/publication/236784951_Next_to_the_Customer's_Heart_and_Wallet_Frameworks_for_exploring_the_emerging_M-commerce_arena/links/0f31752f35433c1d5a000000.pdf

Saleh, K. (2019). "Global Online Retail Spending – Statistics and Trends." Retrieved from https://www.invespcro.com/blog/global-online-retail-spending-statistics-and-trends/.

Sambasivan, M., Patrick Wemyss, G., & Che Rose, R. (2010). User Acceptance of a G2B System: A case of Electronic Procurement System in Malaysia. *Internet Research*, *20*(2), 169-187.

Sanders, J. (2019) How 5G will affect augmented reality and virtual reality. *ZDNet*, (October 2). Retrieved from https://www.zdnet.com/article/how-5g-will-affect-augmented-reality-and-virtual-reality/

Schofield, G., Beale, G., Beale, N., Fell, M., Hadley, D., Hook, J., ... & Thresh, L. (2018, June). Viking VR: Designing A Virtual Reality Experience for A Museum. In *Proceedings of the 2018 Designing Interactive Systems Conference* (pp. 805-815). ACM.

Serino, M., Cordrey, K., McLaughlin, L., & Milanaik, R. L. (2016). Pokémon Go and Augmented Virtual Reality Games: A Cautionary Commentary for Parents and Pediatricians. *Current Opinion in Pediatrics*, *28*(5), 673-677.

Seymour, N. E., Gallagher, A. G., Roman, S. A., O'brien, M. K., Bansal, V. K., Andersen, D. K., & Satava, R. M. (2002). Virtual Reality Training Improves Operating Room Performance: Results of A Randomized, Double-blinded Study. *Annals of Surgery*, *236*(4), 458.

Smith, B., & Linden, G. (2017). Two Decades of Recommender Systems at Amazon.com. *IEEE Internet Computing, 21(3),* 12-18.

Song, J., Kim, J., Jones, D. R., Baker, J., & Chin, W. W. (2014). Application Discoverability and User Satisfaction in Mobile Application Stores: An Environmental Psychology Perspective. *Decision Support Systems, 59*, 37-51.

Speicher, M., Hell, P., Daiber, F., Simeone, A., Kr, A., #252, & ger. (2018). A Virtual Reality Shopping Experience Using the Apartment Metaphor. *presented at the meeting of the Proceedings of the 2018 International Conference on Advanced Visual Interfaces, Castiglione della Pescaia, Grosseto, Italy*.

Sprout, R. T., & Sprout, S. M. (2002). Interactive Virtual Reality Performance Theater Entertainment System. *U.S. Patent No. 6,409,599*. Washington, DC: U.S. Patent and Trademark Office.

Steuer, J. (1992). Defining Virtual Reality: Dimensions Determining Telepresence. *Journal of Communication*, *42*(4), 73-93.

Swapana, M., & Padmavathy, C. (2017). Factors Influencing Online Shopping Experience - A Conceptual Model and Implications. *Global Management Review, 11*(1), 18-26.

Templier, M., & Paré, G. (2015). A Framework for Guiding and Evaluating Literature Reviews. *Communications of the Association for Information Systems*, *37*(1), 6.

Tian, L., Yunwu, W., & Chao, D. (2017). Looking at 'Education+' from the Perspective of 'Buy+'. *China Medical Education Technology* (3), 2.

Trevinal, A. M., & Stenger, T. (2014). Toward a Conceptualization of the Online Shopping Experience. *Journal of Retailing and Consumer Services*, *21*(3), 314-326.

Troutman, M., & Timpson, S. (2008). Effective Optimization of Web Sites for Mobile Access: the Transition from eCommerce to mCommerce. *Journal of Interactive Advertising*, *9*(1), 65-70.

Van Krevelen, D., & Poelman, R. (2007). Augmented Reality: Technologies, Applications, and Limitations. *Vrije Universiteit Amsterdam, Department of Computer Science, 368.*

Venkataraman, S. and R. T. Haftka (2004). Structural Optimization Complexity: What has Moore's Law Done for Us? *Structural and Multidisciplinary Optimization,* 28(6): 375-387.

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to Learning and Schooling in the Digital Networked World of the 21st Century. *Journal of Computer Assisted Learning*, *29*(5), 403-413.

Warburton, S. (2009). Second Life in Higher Education: Assessing the Potential for and the Barriers to Deploying Virtual Worlds in Learning and Teaching. *British Journal of Educational Technology*, *40*(3), 414-426.

Wikipedia contributors. (2019, September 9). Anaglyph 3D. In *Wikipedia, The Free Encyclopedia*. Retrieved December 10, 2019, from https://en.wikipedia.org/w/index.php?title=Anaglyph_3D&oldid=914806538

Westphal, C. (2017). Challenges in Networking to Support Augmented Reality and Virtual Reality. *IEEE ICNC*.

Xin, X., Zhou, W., Li, M., Wang, H., Xu, H., Fan, Y., ... & Zhu, D. (2017, July). Innovation Design in Personal Center Interface of Mobile Application. In *International Conference of Design, User Experience, and Usability* (pp. 310-323). Springer, Cham

Xu, Z. (2018). Essays on Online Retailing in Emerging Markets (Order No. 10826202). *Available from ProQuest Dissertations & Theses Global. (2128140437).*

Yang, S., & Xiong, G. (2019). Try It On! Contingency Effects of Virtual Fitting Rooms. *Journal of Management Information Systems, 36(3),* 789-822.

Zhang, X., & Wong, L. Y. (2014). Virtual fitting: Real-time Garment Simulation for Online Shopping. *presented at the Meeting of the ACM SIGGRAPH 2014 Posters, Vancouver, Canada*. Retrieved from https://doi.org/10.1145/2614217.2633388

Appendix: List of Articles Used for the Literature Review

	Reference	Methodology	Key Concepts	Findings
1	Lécuyer, A., Lotte, F., Reilly, R. B., Leeb, R., Hirose, M., & Slater, M. (2008)	Experiment	Brain-computer interaction	Brain-computer interaction can overcome the inconvenience of interaction in virtual environments
2	Funahashi, K., Ichino, M., & Teshigahara, M. (2009)	Experiment	haptic and force feedback gloves for VR shopping	Force feedback gloves can make the VR shopping experience better
3	Bamarouf, Y. A., & Smith, S. P. (2010)	Experiment	Haptic feedback, haptically enabled online shopping	Developing a glove to provide a "touch-like" feeling in a virtual environment, enhancing the virtual reality experience
4	Magnenat-Thalmann, N., Kevelham, B., Volino, P., Kasap, M., & Lyard, E. (2011).	Simulation	Customer satisfaction, product evaluation	Develop the "Virtual Try On" (VTO) application to help consumers evaluate apparel when shopping online
5	Mosteller, J., Donthu, N., & Eroglu, S. (2014).	Experiment	Cognitive effort, aesthetic, Online Shopping	Aesthetic-related experiences shape perceptions of cognitive effort among different types of consumers
6	Ohta, Y., & Tamura, H. (2014)	Experiment	Mixed Reality	Mixed reality can be a solution for virtual shopping, because of its low cost and relatively lower entry barriers.
7	Muta, M., Mukai, K., Toumoto, R., Okuzono, M., Hoshino, J., Hirano, H., & Masuko, S. (2014).	Experiment	Virtual shopping, Multiple people, real time chatting, Cyber chamber system	The Cyber Chamber system allows multiple people to shop together in a virtual environment
8	Zhang, X., & Wong, L. Y. (2014)	Experiment	Virtual Fitting, Real-time simulation, physically based simulation	AR/VR technology combined with neural machine learning can improve apparel fitting, and can be very scalable and extensible
9	Altarteer, S., Vassilis, C., Harrison, D., & Chan, W. (2016)	Experiment	Online retailing, Product customization & Visualization, Luxury brand	Advancement in hardware and software technologies combined with product visualization & customization can enhance the shopping experience

10	Xin, X., Zhou, W., Li, M., Wang, H., Xu, H., Fan, Y., ... & Zhu, D. (2017)	Book	Innovation design, User interface, Mobile Internet	Mobile Internet economy has grown recently and is flourishing. A good interface will benefit mobile shopping applications.
11	Bastug, E., Bennis, M., Médard, M., & Debbah, M. (2017)	Study	An overview of AR/VR opportunities, challenges, enablers and environment	Possible futures of AR/VR-related futures identified. Challenges include cloud computing, tracking accuracy, and network speed limits.
12	Akiyama, G., & Hsieh, R. (2018)	Project Experiment	Data visualization, Web marketing, online interacting	Online service interactions can enhance the online shopping environment, and data visualization can help improve the service level in online environments.
13	Izogo, E. E., & Jayawardhena, C. (2018)	Netnographic Study	E-retailing, internal and external responses to service quality	The online shopping experience varies based on consumers' cognition, perceptions, and behavioral experiences.
14	Bonetti, F., Warnaby, G., & Quinn, L. (2018)	Review and Synthesis	AR/VR in physical and online retailing	Identifies need for better AR/VR interfaces for customers and increased collaboration between AR/VR technology vendors and online retailers to develop marketing and retailing strategies to enhance consumers' shopping experience
15	Speicher, M., Hell, P., Daiber, F., Simeone, A., & Krüger, A. (2018)	Experiment	3D interaction in virtual environment, Online property selling	AR/VR has been applied for property sales because it enables remote property viewing.
16	Chung, S., Kramer, T., & Wong, E. M. (2018)	Experiment	Touchable device, Touch interface, Affect	The device of choice can affect people's shopping intention. Emotional factors are important when researching online retail.
17	Huber, F., Hohlbaum, M. F., Baumann, T. C., & Schürmann, K. (2018).	Experiment	Website display, 2D display, Switch 2D display to Virtual	AR/VR can help build a fully immersive interface by switching displaying method from 2D to virtual
18	Yang, S., & Xiong, G. (2019).	Field experiments	VR application in online retailing, virtual fitting	Finds that virtual fitting rooms improve sales and customer satisfaction, but only when used properly, i.e.

				without conventional product visualizations, to avoid discrepant perceptions.
19	Farah, M. F., Ramadan, Z. B., & Harb, D. H. (2019)	Interviews	Expectations gap	Consumer use of VR comes with the risk that their actual experience does not meet their expectations.