

The study of how XR technologies impact the retail industry, now and in the future.

Breanne Pitt

A research paper submitted to the University of Dublin, in partial fulfilment of the requirements for the degree of Master of Science Interactive Digital Media.

2020

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Abstract

Extended reality (XR) is currently one of the most discussed technologies in the retail sector. While XR applications are presently utilized by a range of retail companies, recent technological developments and societal transformations indicate that these technologies will become a mainstream necessity for success. This paper investigates how XR technologies impact the retail sector, now and in the future. In order to collect substantiated and timely data, this study engages in a multi faceted, qualitative data collection approach including a literature review, attendance at retail conferences and events, and semi-structured interviews with industry experts.

Results reveal the implementation of three types of XR technologies are significant contributors to company success: virtual reality (VR), augmented reality (AR), and mixed reality (MR). They are currently utilized to enhance the customer experience, improve training, conduct consumer behavioral analyses, and develop prototyping for increased efficiency and productivity in product merchandising, packaging and branding. However, implementation of these technologies does not guarantee success. This study indicates success of these applications requires an understanding of each technology's specific affordances in order to effectively integrate them within particular areas of the retail supply chain. Augmented reality is often best suited for consumer applications, while necessary proprietary equipment makes virtual and mixed reality more effective for industrial and enterprise applications. If utilized effectively, these technologies can help increase sales, make the manufacturing workflow more cost effective and efficient, and create a retail landscape that allows for the synchronous success of both brick and mortar stores and ecommerce.

Future XR technologies will look to standardize and simplify, and eventually, there will be a collection of uniform XR experiences that will become conventional, easily integrated, and user friendly. If retailers want to be competitive, both in online and offline shopping, this study emphasizes the need to invest in XR technologies and build flexible tech management teams that prioritize XR as a technological resource, and restructure businesses to easily adapt to the rapidly changing tech landscape.

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1. INTRODUCTION

This paper will explore different uses of extended reality (XR) technologies in the retail sector, and what the overall impact is on the industry. It will reveal current and potential drawbacks and benefits, past and present implementation and future projects, and overall market readiness for these technologies. The purpose of this chapter is to identify and explain the research topic, aims, and goals, while also indicating the general structure and methodology of the paper.

1.1 Aims and goals

This study aims to synthesise existing literature regarding XR technologies and retail with semi-structured interviews from industry professionals and retail conferences and events. This will provide a well-rounded understanding of the current digital landscape in this sector while also drawing conclusions about the future. The focus will be the following:

- To identify multiple types of XR technologies in existence, and to learn about XR technologies currently being developed.
- To identify what XR technologies are currently being implemented in the retail industry.
- To understand how these XR technologies impact business in areas such as sales, client and employee experience, marketing, etc.
- To understand the potential future impacts of XR technologies in retail.

The goals of the project's research and interviews are:

- To identify and understand different XR technologies that exist, and what potential they have to impact the retail industry.
- To understand what XR technologies have and will be used in the retail industry.

- To study individuals who have experience in the implementation and development of XR technologies in retail.
- To understand some of the problem areas in the retail industry, and how XR technologies have been or could be used as a solution.
- To identify current and previous XR technologies used in retail and their overall successes and failures.
- To understand market readiness for XR technologies in the retail industry.

1.2 Research question and contribution

What is the impact of XR technologies on the retail industry, now and the future?

This research question is the basis around which this paper will develop. An understanding of the range of XR technologies in existence, and how they are effectively and ineffectively being implemented in industry can result in a more efficient business model for retail companies. This can also lead to an opportunity to develop and integrate future XR technologies in the retail market.

To answer the research question within the time allotted for this project, the subsequent methodology will be used.

1.3 Methodology

In order to investigate the research question, this study engages in a multi-faceted approach. This included three qualitative data collection methods: a literature review, attendance at industry conferences and events, and two, semi-structured interviews with industry experts. In order to present and analyse this data, the academic system of coding and theming was used to recognize emergent themes and synthesize the content into a cohesive, structured discourse. This method was implemented, paired with inductive and deductive reasoning, to draw sound conclusions regarding XR and its impact on the current and future retail industry.

Qualitative data collection for method one involved a thorough literature review. It was important to break down the key research components and understand them independently before delving in to personal interviews. These components included a deeper understanding of the different XR technologies in existence, their technological affordances, their current applications in the retail sector, and a basic understanding of the retail industry's past and present trends, obstacles, challenges, and opportunities. For this, academic literature was reviewed to identify key XR technologies and develop comprehensive definitions to use for the purpose of this paper. Research was also conducted into the history of different XR applications to better understand the purpose of their development and their technological affordances. It was also important to investigate content regarding the retail industry independent of XR technologies to develop a holistic view of the sector's trends, obstacles, challenges, and opportunities.

Method two required attendance at several industry events, conferences or meetups. Originally, attendance at seven events was anticipated, but due to the outbreak of Covid 19 and measures taken by the Irish Government to contain the spreading of the virus, four of the events were canceled. However, three events were attended, which provided an adequate collection of data to work with effectively. Two of these events provided insight into new XR applications being developed and the successes of current technologies already being implemented. Also, these events enabled first-hand engagement with XR products while providing networking opportunities with industry professionals, one of which became an interviewee, Expert 1. The third event focused mostly on marketing and the collection of data within the retail industry. At this event, obstacles retail researchers face were revealed, along with methods they use to engage and build their client base.

For method three, two semi-structured interviews with industry professionals were conducted. These professionals were involved in either the development or utilization of XR technologies in the workplace. Ethical approval for this research was sought from the Ethics Committee of the School of Computer Science and Statistics, Trinity College Dublin. An application was submitted 31 January 2020, and approval

was granted on the 14th of April. The first interview was conducted with Expert 1 in April via Skype, as Dublin was on lockdown due to the government measures set for by the HSE due to Covid 19. Data collected from this interview was used to obtain an up-to-date, real-world understanding of the XR landscape within the retail sector, and to learn about current and future applications software engineers are designing. Particularly, this interview focused on the purpose of using XR in regards to interactions with the consumer directly. The interview with Expert 2 allowed for insight into XR technologies implemented from an industrial and enterprise perspective. Expert 2 also had first-hand knowledge of using XR applications in the workplace to create retail products.

Lastly, after collecting research through the three aforementioned data collection strategies, the method of triangulation was used to draw conclusions about how different XR technologies lend themselves to improving retail ventures. Therefore, informed conclusions were developed regarding the research questions alongside sound predictions on how XR may change the retail landscape in the future.

1.4 Paper structure

This research paper consists of six sections. Chapter 1 includes the topic introduction, which discusses the goals and aims for this research, the research question and contribution, methodology and paper structure.

The literature review is presented in Chapter 2, where XR technologies are defined for the purposes of this paper. The literature review covers a brief history of XR, current XR technological applications, and an overview of the 20th century retail landscape among other subjects.

In Chapter 3, a further understanding of XR in the retail sector was collected at different industry events throughout the year. These included two events held by XR Dublin titled *XR in Retail* and *XR in Manufacturing*, a third event held at the Dogpatch labs in the CHQ building organized by Adtower and Quividi called

Engaging "Brand Conscious" Shoppers with DOOH - The Importance of Live Data in a Performance Marketing Era, and lastly the *3Dcamp Dublin & Irish VR meetup* held at Workday, King's Building in Dublin.

As a next step in Chapter 4, the results of the semi-structured interviews are presented. Due to time constraints, difficulty with access, and other problems which arose due to the outbreak of Covid 19, only two interviews were conducted of the original three scheduled candidates. The results of these interviews are presented and analysed in this chapter, which include discussions on current market trends and future applications.

The final conclusions are set forth in Chapter 5, and are drawn from the qualitative data collected in the literature review, attendance at conferences and events, and interviews.

2. Literature Review

In order to explore how XR technologies impact the retail industry, we need to first understand the three categories of XR Technologies. It is also important to look at the retail industry and study current business trends, consumer behaviors, and the uses of XR technologies in this sector, both the successes and failures. Furthermore, in order to predict the future of XR in the retail industry, it is also necessary to investigate the market readiness for these technologies.

In order to explore the research question through conducting a literature review, several databases were utilized, including ScienceDirect and Google Scholar, to explore scholarly journals, books and articles. Due to the nature of this area of study, and because this is an emerging field, several websites and industry reports were also reviewed.

2.1 What are XR technologies?

The concept of XR emerged in the mid-1900s, but it wasn't till the later half of the century that it became a pillar of mainstream technological discussion and advancement. XR technology, or extended reality technology, is an umbrella term for all immersive technologies: technologies that attempt to imitate the physical world through the digitization and simulation of sensory experience. It refers to a wide array of hardware and software, like sensory interfaces, applications, and even wearables. But what are the purposes of these technologies? How are they being used? Currently, they are being implemented in almost every line of work, from architecture to medicine. When discussing XR, especially for the purposes of this paper, I will be referring to the three most common of these immersive technologies, which are virtual reality (VR), augmented reality (AR), and mixed/merged reality (MR) (Johnson).

2.1.1 Virtual reality (VR)

The evolution of XR Technologies began with Virtual Reality (VR), an interactive, multisensory, immersive experience in a simulated environment. It arguably surfaced in 1962 with Morthon Heilig's arcade game prototype the "Sensorama", which was one of the first successfully created virtual environments where the user experienced more than just a visual display. Instead, they experienced a first-person view of a motorcycle speeding through New York City while hearing "three-dimensional binaural sound" that simulated the sounds of New York City with a motorcycle moving through it (Fisher 1). Throughout the experience, when the user "leaned [his/her] arms on the handlebar platform built into the prototype and sat in the seat, simulated vibration cues were presented. The prototype also had a fan for wind simulation that combined with a chemical smell bank to blow simulated smells in the viewer's face" (Fisher 1).

A few years later, Ivan Sutherland's 1965 essay "The Ultimate Display" became a catalyst for the VR movement. In this essay, he discussed the possibility of a kinesthetic display that would allow people to experience objects or realizations that are not reachable in the physical world. He stated, "There is no reason why the objects displayed by a computer have to follow the ordinary rules of physical reality...by working with such displays of mathematical phenomena we can learn to know them as well as we know our own natural world" (Sutherland 506). He further describes that these displays should serve as many senses as possible.

"The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal" (Sutherland 508).

This essay was a simulant for the VR movement, and many of his predictions, like the "machines to sense and interpret eye motion data" are some of the most commonly used VR technologies in existence. It wasn't till the 1990s when VR

moved from experimental to commercialized, and items like the VPL Dataglove (Badler 82) and virtual video gaming headsets like the CyberMaxx (Mazuryk 46) were released.

2.1.2 Augmented reality (AR)

Augmented reality involves the blending of real-world environments with interactive digital elements as a means of enhancing reality. The term was first coined in 1990 by Boeing researcher Tom Caddell (*Figure 1*). He used it to describe the digital display electricians used which mixed virtual graphics on physical reality. Augmented reality became mainstream when it was incorporated into entertainment venues, like “when analysts draw on their screens during sporting events or when graphics are displayed live,” (Pope 5). It has most recently become famous through the creation of cellular applications, like Pokemon Go and the filters on Instagram and Snapchat.

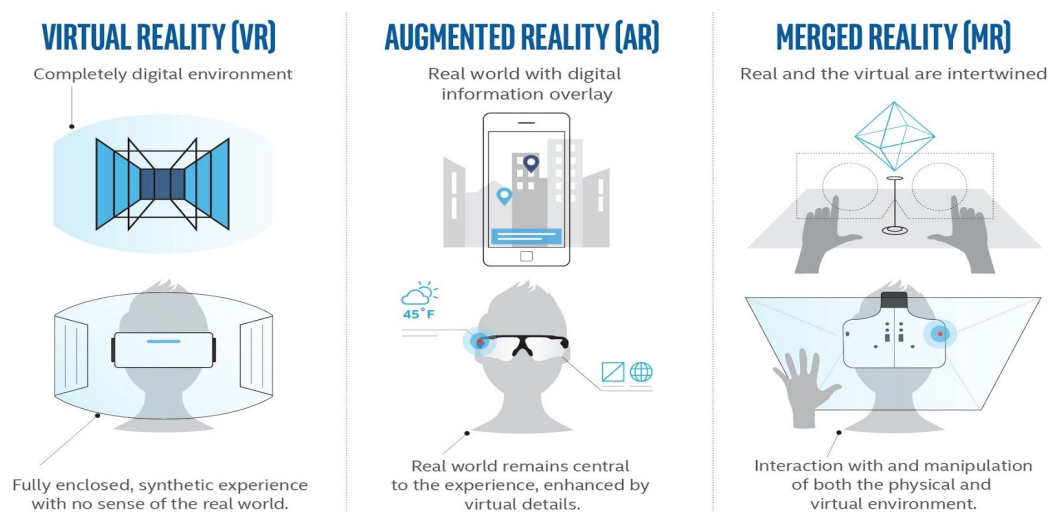


Figure 1: Diagram showcasing the complex differences between VR, AR and MR (Soni)

2.1.3 Mixed/Merged reality (MR)

Mixed reality, also known as merged reality, is a term only loosely identified, and definitions are largely subjective. MR can be many things and its understanding is

always based on one's context (Speicher 12). In basic terms, mixed reality is a combination of a real and virtual environment, where the user is able to interact and manipulate both. This is slightly different from augmented reality, where the real world remains central and is merely enhanced by digital objects “The term Mixed Reality (MR)—sometimes referred to as Hybrid Reality—applies to everything in between the real world and a virtual world.”(Çöltekin).

The concept of mixed reality became popularized by academics Fumio Kishino and Paul Milgram in the 1990s. They felt that mixed reality involved “the merging of real and virtual worlds somewhere along the ‘virtuality continuum’ which connects completely real environments to completely virtual ones,” (Milgram 1).

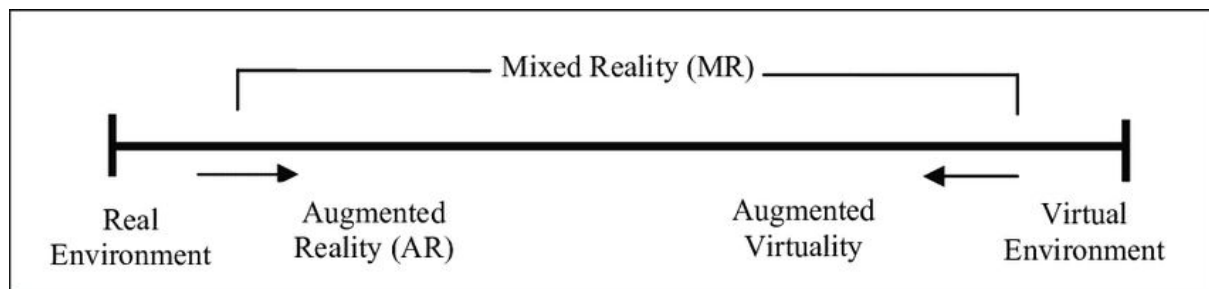


Figure 2: Mixed reality continuum described by Kishino and Milgram (Yuen)

While the mixed reality continuum described by Milgram and Kishino (*Figure2*) serves as an adequate reference framework to classify the different realities, it is not officially accepted, and some academics find it theoretically confusing. Therefore, “the boundaries between different realities (virtual, augmented, mixed) have not been properly defined in the literature, and there seems to be no consensus in practitioners' use of these terms when developing and releasing new devices,”(Flavián). However, because there is no better, academically accepted alternative and this is a flexible continuum, for the purposes of this paper, Milgram and Kishino's continuum will be used in order to best understand the concept of mixed reality.

2.2 Retail Industry Overview

2.2.1 Task of the retailer and internationalization

The Retail Supply Chain consists largely of manufacturers, wholesalers, retailers and consumers. Therefore, when using the terms 'retail sector' or 'retail industry' in this research paper, I am referring to all facets of the chain mentioned above. The task of the retailer is to simplify the process of purchasing the goods or services for the customers that manufacturers cannot provide. The manufacturer creates the product while the wholesaler is the individual or company that sells the product in large quantities at discounted prices to a retailer. The retailer displays the product and its features, stock the products, process the payments and does everything to ensure that the right customer receives the right product or service at the right time. (Farfan 2018.)

Therefore, the internationalization of the retail sector also became important. With globalisation, the markets are open to explore, and some manufacturers cannot set up their expensive manufacturing units in different countries. However, the goods can be retailed to different countries making it more profitable for the retail companies. With the growth of the internet in the 2000s, the retail sector yet again underwent major changes. E-commerce or internet retailing has been adopted as the new shopping style by the consumers. The overall internet retail sector has tripled in the past few years, but brick and mortar remain the major contributor of the retail sector revenue. (Mordor Intelligence 2018.)

2.2.2 Retail industry outlook - use of technology and barriers

There are multiple ways in which the retail industry utilizes technology. These include, but are not limited to, high tech tools that improve product design, market research, e-commerce, customer relationship management (CRM), inventory tracking, and data warehousing (Lipow). However, due to the rapid speed in which technology advances, it is no easy task for companies to effectively invest and

implement trending technologies. For example, “Forty-nine percent of CMOs indicate that tech management is still too slow to meet their needs — the pressure is now on for CIOs to replace slow and complex tech with fast and simple solutions to get to market faster” (Forrester). The implementation of new technologies often requires company restructuring and major financial investments, plus it is also a point of contention between executives and an aging workforce (Crum 353). Regardless, in order to be competitive in the marketplace, it is now “more important than ever for businesses to embrace emerging and disruptive technologies companies,”(Rossi).

A key factor for success in the retail industry is the effective management of the customer experience. The customer experience can be defined as the “cognitive, emotional, behavioral sensorial and social responses to a firm’s offering during the customer’s entire purchase journey” (Lemon 71). Customers have several interactions, or ‘touchpoints’, with companies throughout the steps in their decision-making process, “and these sensory, affective, behavioral and intellectual sub-experiences form the fundamental customer shopping experience “(Brakus).

Forbes acknowledged that providing emotionally engaging customer experiences during the decision making process was a marketing trend for 2018 (Forbes). This succeeded a 2016 study done by Forrester, where data showed that 72% of businesses believe improving the customer experience is their top priority. However, of those businesses, only 63% prioritize implementing technology investments to support this goal (Forrester). Therefore, there is a significant gap between a company’s stated priorities and actual implementation of said priorities. This is due to a multitude of reasons, including inefficient tech management and the rapid pace in which technology changes, which requires an adaptive technology infrastructure that continuously changes to fit customer expectations (Forrester).

The process of integrating technology is central to managing the modern-day consumer experience because business can provide purchasers with added value propositions and optimize the customer experience with unique, individualized virtual ‘touchpoints’. According to the Harvard Business Review, a value proposition can be

defined as identifying and communicating a product's "benefits, favorable points of difference, and resonating focus," (Reynoso 2). In other words, a value proposition communicates a product's added benefit, explains how this particular product is superior to similar products on the market, and clearly identifies how a product fills a need. Therefore, by using emerging technologies, like AR, VR, and MR as added value propositions, consumer-end businesses can enhance and personalize the customer's purchase experience, and strongly influence their decision-making process.

In a study done on customer experiences in the tourism industry through Bournemouth University, researchers broke down the consumer's interaction with the business into an "experience hierarchy". While this study mainly focuses on the tourism sector, the analysis of the customer experience has cross-industry compatibilities, and therefore can be applied to the retail sector as well. The described "experience hierarchy" included four levels of experience: a conventional experience which involves the business communicating directly with the consumer without technology, a technology assisted experience where tech plays a role but does not enable to consumer to create or interact, a technology enhanced experience where the consumers shape their experiences through the use of technology, and lastly technology empowered experience, where AR and VR technologies are required for the experiences (Neuhofer). While MR technologies are not included in this study, AR and VR applications are, they are necessary to create added value to the consumer by providing them with the ability to shape their own experience.

2.3 Retail industry and XR integration

2.2.3 Past XR technologies in retail and impact on current market readiness

There is limited academic literature covering the failures of XR technologies in the retail industry. This can be attributed to the lack of focus on the retail industry as an academic area of study, the rapid pace in which technology changes, or the recent

movement of XR technologies, particular VR, from the entertainment industry into the mainstream retail market. Discussion regarding the failures of high profile XR technologies exist online, but are largely presumptive and opinion based. Ultimately, the consensus seems to be that the failures involving VR were caused by clunky headsets, a dearth of content, and high price points (Pickup).

In other XR applications, perhaps the most high profile product failure was Google Glass, which sparked significant hype in the retail industry, specifically how it could be leveraged for sales purposes. The Google Glass prototype was on the market for less than a year, as it was riddled with flaws including privacy issues, health concerns, and others (Kumar). The failure of Google Glass potentially tainted investment opportunities for trending XR technologies, labeling them as mercurial by nature and unreliable, ultimately preventing industries from buying into new tech until it is more thoroughly vetted (Doyle). This ultimately impacted the market's readiness to accept and integrate these technologies into their business structure.

2.2.4 Present XR technologies in retail

One of the ways in which XR technologies are currently being used in the retail industry is to improve customer experience. Examples of XR uses can be found in three separate purchase stages: pre-purchase, consumption, and post-purchase. A 2019 article in the Journal of Business Research titled "The impact of virtual, augmented and mixed reality technologies on the customer experience", describes how AR and VR technologies can impact all three of these stages. In the pre-purchase stage, "the consumer may "try on" clothes before going to a store - with AR applications, or anticipate the experience of riding a roller coaster with a VR HMD", while in the consumption stage, "consumers might use VR devices to study the wine making process during a wine-tasting session. Or they might look at real-time GPS information on their windshields while driving, thanks to AR developments," (Flavián). Finally, in the post-purchase stage, "the consumer might receive immediate assistance as to how to repair a washing machine, using MR glasses, or create a 360-degree VR video about a recently taken trip," (Flavián).

Another way in which the retail industry is utilizing XR technologies include product design, prototyping, and consumer research. In a 2019 study conducted by Statista, a Statistics Portal for Market Data, “96.3 percent of XR professionals surveyed worldwide identifying product design and prototyping as the main area of the business where XR is used, and 46.3 percent of respondents highlighted this area of the business as where augmented reality or mixed reality (AR/MR) technology was being used,” (“Areas of Business Where XR Is Used”).

L’Oreal is on the frontline of pioneering emerging XR applications, both on the consumer experience and internal prototyping front. While L’Oreal products were traditionally sold in other retail stores, they now also have their own branded stores. At these outlets, customers can engage with an augmented reality application called the Genius App. This app allows customers to use their smartphones to take photos of themselves and apply products on their nails, eyes, and lips virtually. This provides customers with a more appealing shopping experience than traditional environments (Mann). They can create their own experience, uniquely catered to them, where they can test products prior to purchasing. In effect, this saves L’Oreal costs on returns and testers, while also increasing customer satisfaction.

L’Oreal is not just using XR technologies on-site. They are also internally using applications to promote sales and decrease product time-to-market. In the New York City headquarters, L’Oreal encourages use of their VR room to increase efficiency and productivity in product merchandising, packaging and branding. In this lab, they replicate “the full shopping experience from the discovery of the product on the shelf all the way to a satisfied purchase. This means that for every product, they have to build a full prototype of their shelf display”(Chan). Without the VR Lab, the process “can take months, from brainstorm to launch — can be turned around in a matter of weeks in the Beauty Lab. Thanks to the visuals of the virtual reality and 3D renderings, brands can save money and time on creating prototypes and recreating in-store demos”(Milnes).

L’Oreal is not the only company who has embraced XR trends. Companies like Volvo, Lowes, and others have also entered this emerging technology’s arena. For example, Volvo partnered with Varjo, a XR hardware and software company, to create the world’s first MR test drive utilized for car development. In a 2019 press release, Volvo announced they are now able to use a “mixed reality approach to evaluating prototypes, designs and active safety technologies,” (“Volvo Cars and Varjo”). In this application, the driver wears a mixed reality headset while operating the vehicle, and virtual elements are added as obstacles, like deer crossings, to analyse how the car and driver respond. They have also integrated highly accurate eye-tracking technology to make it “easy to assess how drivers use a new functionality and whether they are distracted in any way. This technology-based approach to measuring distraction levels ensures that Volvo Cars can develop new features without causing additional distraction”(“Volvo Cars and Varjo”). Ultimately, Volvo claims the integration of this technology into their car development operations has enabled them to decrease costs by identifying issues much earlier in the design and development process and speed up car production.

3. Conference, Meetup and Event Research

In order to explore how XR technologies impact the retail industry, this study involved attendance at several industry events, conferences or meetups. The purpose of attendance was to develop an understanding of the most up-to-date XR trends while also networking and recruiting potential interviews for this study. Originally, planned attendance included 7 events. Unfortunately, due to the outbreak of Covid 19 and the measures taken by the Irish Government to contain the spreading of the virus, several of the events were canceled. Two of the events attended enabled an understanding of new XR applications being developed, the successes of current technologies already being implemented, and networking with industry professionals, one of which became an interviewee, Expert 1. The third event focused more on marketing and the collection of data within the retail industry. At this event, obstacles researchers face in the current retail landscape were revealed, but it also became prevalent that immersive technologies are appearing in every facet of the industry, from data collection to the sales floor.

3.1. XR Dublin - XR in Retail

The session XR in Retail was hosted on the 16th of October 2019 by XR Dublin at Walmart Labs. It explored the potential for immersive technology in retail. It also discussed questions like what are the current best-in-class applications supporting XR in retail? What are the best-practices for employing 3D models on the web? Does XR have an operational benefit for pre-visualizing marketing assets, product presentation, and collaborating with suppliers?

The session provided perspectives by representatives from three levels of the immersive technology sector: an executive, a craftsman, and an artist. The Executive addressed the topic from a business development and strategy angle while The Craftsman from an implementation and management angle, and the artist from a creative development and design angle. For the purposes of exploring this research

question, the sessions by The Executive and The Craftsmen were most relevant, and are discussed below.

The Craftsman, Allen Wixted, is the founder of NoPlaceLike.co. He was a former Apple employee, and has been making content and digital experiences for retail since 2014. He received the accolade of Limerick's Best Young Entrepreneur 2019, and currently works to build platforms for brands to create and deliver high-quality, realistic, 3D models of their products in Augmented Reality.

Wixted started his session discussing statistics with the audience to validate his product. He set up his pitch by presenting the problem, which was how in 2016 alone, returned products cost the UK retail industry 60 billion Euro. Since 81% of Irish people have an AR compatible iPhone as of 2019, AR was a solution. The application he currently works on uses augmented reality to superimpose furniture from leading brands into people's homes. The application allows the consumer to visualize how the furniture will look in a specific spot in their home, and also important, whether or not it will fit (*Figure 3*).



Figure 3: Image Wixted's slide indicating the key benefits of his AR technologies

After the implementation of this application into the company's customer experience funnel, the organization reported a boost in Average Revenue Per User (ARPU), excellent engagement, specifically increased page views and time on site, improved

service marketing and customer experience, less returns, and an increased “add to cart” action (Wixted).

For The Executive, the session welcomed Jarlath Mahon, Senior Commercial Strategy Manager at Kellogg's, who was interested in the future of XR. He was presented with pitches from two Irish companies that offered immersive technology

solutions focusing on product, consumer engagement, or retail presence.

Of particular interest in this presentation was Darragh O'Brien's pitch. Darragh O'Brien is the Director of Pre-Sales Engineering at Digisoft, a high-tech software solution provider and systems integrator for telecoms, media, industrial and life science industries. His presentation relayed how XR applies to retail, and he broke it down into three main use cases: consumer applications, industrial applications, and enterprise applications. While each XR technologies discussed in this paper can be used for all applications above, O'Brien's claim was that they have individual affordances which make them more prevalent in certain categories. For example, consumer applications generally involve AR technologies (Figure 4).

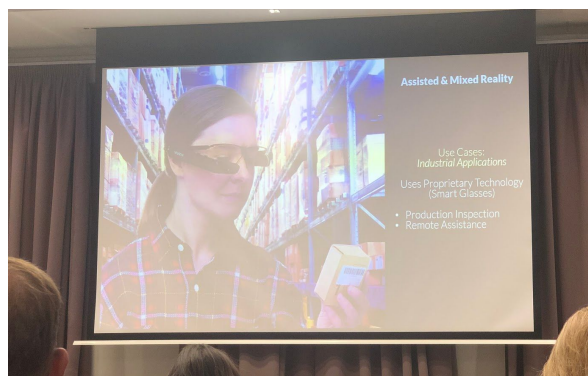


Figure 4: Above images O'Brien's slides depicting XR applications, hardware, and uses.

Consumers have access to tablets or smartphones they can use to interact with a product. This allows for brand engagement and improved consumer assistance and experience. VR and XR require proprietary technologies like VR headsets, sensors and smart glasses, which make them more prevalent in industrial and enterprise applications. While there are uses for VR applications in the consumer category, generally the bulky equipment and extended set-up times are deterrent, especially when the goal is to make a quick sale. Industrial applications can include uses like production inspections and remote assistance while enterprise applications might include enterprise training and behavioral analysis.

After laying out the three main use cases, he discussed how his pitch involved focusing on how to utilize VR combined with eye tracking, heart rate monitoring, and galvanic skin response sensors to conduct consumer behavioral analyses. His company creates virtual environments to study eye tracking in order to discover how shoppers navigate through aisles of a store, what attracts their attention at the point of purchase, what visual elements are noticed and ignored, what elements help at different stages in the decision process, and how they interact with products on the shelf. The study of consumer behavior helps drive decision making with regards to product placement, design, sales methods, etc (O'Brien).

3.2 Adtower and Quividi - *Engaging "Brand Conscious" Shoppers with DOOH- The Importance of Live Data in a Performance Marketing Era*

At this event on the 3rd of Dec 2019, there were presenters from Adtower, Quividi and Intel who discussed how real-time audience data for digital out-of-home (DOOH) creates new revenue opportunities for marketers. Presenters detailed the transformation impacting consumer measurement for DOOH and showcased actual cases that leverage contextually data-driven and programmatic DOOH campaigns to increase ad engagement and in-store sales (Roth).

The purpose in attending this event was to garner insight into how the retail industry collects data and utilizes it to increase sales. To explore the research question, it was important to understand the way in which the retail sector operates in order to fully comprehend how XR impacts the industry. However, it was notable that every presentation, from marketing and sales to product development, was engulfed with the discussion XR technologies.

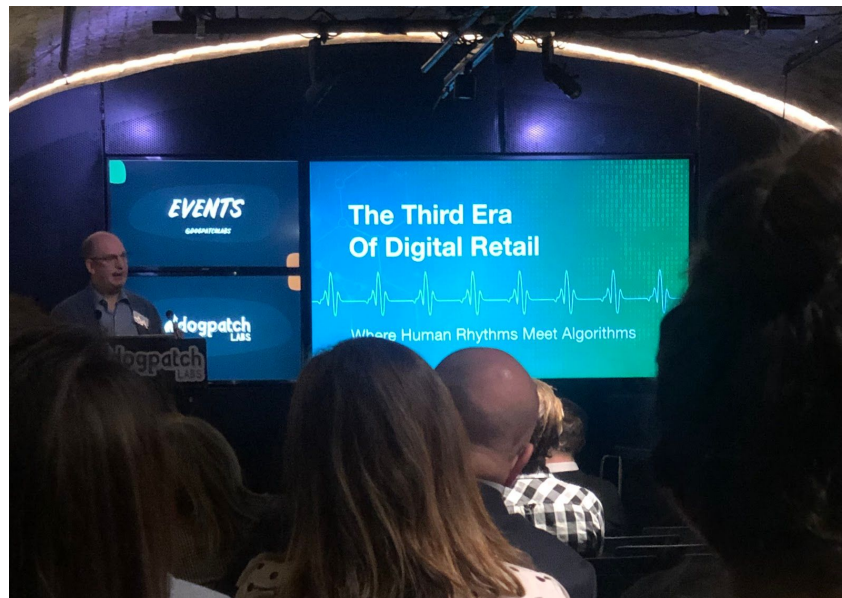


Figure 5: Image of David Roth's slide depicting his theory of the 'Third Era of Digital Retail'

Specifically relevant was the session by David Roth, the CEO of The Store WPP, EMEA and an expert on retail in Asia. He opened the event with the statement that we are entering the “third era of digital retail, where human rhythms meet human algorithms”. He discussed the importance of not believing that technology and humans are opposites, but instead that we are connected and can peacefully coexist together, as long as we move with the curve instead of against it (*Figure 5*).

One of the examples he discussed was how companies in China are combining both virtual stores and physical retail space, and how this is the wave of the future. Examples provided included Suning.com, a leading physical and e-commerce retailer in China with over 8,881 stores across the nation. Its shareholder Alibaba, is a multinational tech megagiant that specializes in e-commerce, retail, internet, and technology. This partnership gives Alibaba access to more physical space in China,

which is advantageous because of its growing network of physical stores called Hema. At Hema, customers are able to buy their groceries both on and offline, and delivery for online products is guaranteed within 30 minutes for local customers. They even have special events which utilize XR technologies to draw customers to the stores, like when Alibaba introduced an augmented reality game named Catch the Cat, which was similar to Pokemon Go. According to Roth, the necessity of having both physical and virtual retailing is key to success, but only if an organization can also digitise the entire supply chain. By jointly embracing technology, manufacturers, wholesalers, and retailers can create and sell products more efficiently (Roth).

3.3 3Dcamp Dublin & Irish VR meetup

This meetup was held at Workday on the 6th of Feb 2020, and featured presentations, demos and discussions. The presentations included “80VR Drama: Intimate spaces and private moments”, “Understanding Truly Immersive Multimedia Experiences”, “Designing in Space - CosmosVR”, and “Creating Virtual Objects to Simulate Real World Objects”.

Of particular interest to this study was Cordula Hansen’s presentation on designing in space. Cordula Hansen is a VR Designer and 3D Content Creator in Dublin, and her presentation explored current challenges in collaboration and data visualisation with VR. She presented CosmosVR, which was a data visualization dashboard. Specifically, her project helps users explore blockchain data from the Cosmos network, which was unrelated to my research. However, data visualization was discussed, and provided insight into how VR visualizations make it possible to offer easier pattern recognition and recall for the user. The capabilities of augmented reality and virtual reality could be applied to data visualization, in which a user can organize data in space, rather than on a flat, 2D screen. This could be particularly helpful to people who are spatially adept, or those who are visual and kinesthetic learners. In the retail industry, VR for data visualization could be used to enhance data mining, the process of studying sizable pre-existing databases to develop new

information. However, obvious concerns came out among participants regarding VR displays and helmets and whether accessibility to this hardware would work in an office setting, but its benefits for exploring blockchain data from the Cosmos network was clear. Regardless, the future potential of standardising and integrating VR data visualisation software in the retail space shows potential, but currently the market is not ready and the software needs time to develop and simplify (Hansen).

4. Results from Interviews and Analysis

For the purpose of garnering real-time data regarding the present state of XR in the workforce, I conducted two semi-structured interviews with experts involved with the development and utilization of immersive technologies. XR technologies are rapidly advancing, and in order to answer the research question, it was important to obtain current, real-time information. The candidates chosen are industry professionals, and were recruited through networking events like workshops, conferences, meetups, or personal contacts. All participants were over the age of 18. Data was solely used for my own research purposes and the two interviewees identities and workplaces were kept anonymous and confidential. Expert 1 works as a software engineer for an international software development company and helps design XR products. Specifically, the company, among many ventures, works with the creation of frameworks purpose-built for AR and VR development. Expert 2 works as a program manager and tooling engineer for a contract manufacturing partner company, and has experience using XR technologies for enterprise applications. After conducting the interviews, further analysis was required, which involved engaging in the process of coding and theming to identify common discussion issues and viewpoints, which are broken down into the topics below. According to the University of Huddersfield, the process of coding and theming includes identifying 'Themes', which are features of participants' accounts characterising particular perceptions and/or experiences the researcher feels relevant to the research question, and then 'Coding', the process of identifying themes in accounts and attaching labels (codes) to index them ("Themes and Codes").

4.1 The current state of augmented reality in business

Expert 1 stated the choice in utilizing a specific XR technology "depends on the product being sold". However, he felt augmented reality is currently the most popular in retail stores. The reason for this is accessibility. He used the example of an average shopper looking for a product in a shopping mall. They don't want to put significant effort into putting on a VR headset to buy a pair of sunglasses or a hat. It's

impractical to put effort into VR over AR for certain products “because VR is ultimately the hardware heavyweight of the two of them.” AR is very practical and accessible because it's something that can be brought to any device that a person might have, like a cell phone. Contrastingly, VR requires a headset, which is clunky, takes time to be programmed and set up, is more invasive, and also expensive.

Expert 2, the tools engineer, viewed AR as a major influencer from an enterprise and industrial perspective. An area he described as particularly impactful was the use of AR for training. He described his company as an organization with facilities in Ireland, China, Mexico, and several in the US. At these facilities, there are tradesmen in their late 50s and 60s who went through apprenticeship programs to become highly specialized, but now they are aging, and some are retiring. They can't travel nor do physical labor, and these techs are becoming more and more hard to find. AR technology is now being developed and used to enable these experienced industry veterans to help guide the younger, less experienced new hires. They now can teach and facilitate guidance in other buildings all over the world that may not have that same level of experience in their very unique, niche job description. By integrating this technology, companies will no longer need to have an expert on hand at all of their facilities, but instead they can have one person using this technology and covering all of the facilities at the same time. So a tech on the floor who doesn't have the knowledge and experience to know exactly how to troubleshoot specific problems can be led by a remote expert somewhere in the world.

Not only can AR training be used in previously apprenticed positions in factory-like environments, but it can also be applied to training in retail stores. Some retail stores are using augmented reality applications that allow their employees to point their cell phones at merchandise they need to sell, and then acquire instant training specific to the selling of that product.

For both training methods, when asked if this would benefit or hurt the workforce since it seemingly would require less experienced people for training, Expert 2 said “one thing this is going to do is going to help bridge that gap. If anything, I think is

going to bring more opportunities to people.” Essentially, it speeds up the time training would normally take while also providing the opportunity to enable unskilled workers to become knowledgeable and valuable assets to a company.

He further described how this technology works by saying,

“that veteran expert can potentially work with a bunch of five-year experienced techs around the world. When there is a problem that goes well beyond a novice tech’s experience level, the expert can jump in and say, ‘OK, put on your glass, show me what you’re looking at. Show me what the problem is. So this is where you have to move this item or you need to increase your pressures over here’ - and he marks a location on the augmented glasses. ‘Look at this data’ - and then the expert starts circling things on the tech’s screen.”

Basically, an expert tech anywhere in the world can talk to a novice in real time and provide guidance as if they were standing in the room.

4.2 The current state of virtual reality in retail

The first comment Expert 1, the software engineer, made regarding this topic was that VR requires the consumer and provider to put a lot of effort into seeing a single product, and therefore it is more likely to be used in an industrial setting or for a luxury item. Thus, he said,

“Where the customer is a single, unique customer, in the luxury car business for example, that would be something that is actually getting more and more relevant today, because based off of that sort of sale, it’s a single item being sold at a very large price point generally for an individual customer, which is tailored to them, so they want a tailored experience.”

Thus, VR is used in the retail industry where products are more specialized, with a higher price point and a unique consumer.

With Expert 2's experience in the contract manufacturing partner company, he continued to tout XR as a means of training. While he stated above that AR was great for person to person training, he also felt using VR applications were an effective means of training workers in the utmost safe environment. He said, "The great thing about VR is it allows you to create virtual settings. You don't put an individual on the floor where they can get in everyone's way. You can recreate your retail manufacturing floor in a mixed or a virtual reality world, and the person can now train in a safe environment." Safety is a key selling point to both manufacturers and employees. Plus, "There's no physical risk or any danger from any new machine." Also, problem scenarios can be programmed, and there can be a sequence of events the trainee learns to follow in order to correct the situation more directly.

Outside of training, Expert 2 also felt that VR applications significantly benefit prototyping. When a technician creates something in CAD, they can only see it on the screen. But if they want to see how workers on the floor or customers in the store interact with their design, VR allows them to take that 3D data and turn it into a virtual environment. In a manufacturing plant, you can use "the manufacturing cell that we've created through CAD, put it in a virtual plant and view spacing between machines and cells, spacing between components, and how they interact while also assessing how the workflow process is going to be."

4.3 The current state of mixed reality in business

Regarding mixed reality, both Experts admitted to less expertise in the area. Expert 1 said, "to be perfectly honest I haven't actually seen any examples of mixed reality being used in retail...Ultimately, at the end of the day, this service is being used to sell more products. So the idea of using XR in retail is so that it can be given over to the customer so that the customer can be more sure of what they're getting with it." If

a company is to use mixed/merged reality applications, it is because there are multiple approaches that need to be taken. Expert 2 also admitted to knowing few examples of how MR is currently being implemented in retail, but continued his confidence in XR for training, saying that MR applications would be well suited for training a well.

4.4 Market readiness for XR technologies

After posing the question regarding market readiness for XR technologies and advances, three main areas of discussion came up: cost, lack of tech savvy senior management, and availability.

Currently, there are a lot of XR applications available to companies, and these applications have significantly improved over the last few years. According to Expert 1, “it used to be a case that you had to tailor make individual applications, whereas now you can have more broad-scope applications that would be able to be integrated into a particular business.” He also continued by saying that these applications are more user friendly than they had been in the past, and they are continually becoming more and more mainstream, making the integration of these applications inevitable. In essence, the “software has become more and more readily available as people start to see the actual applications of XR within the retail space. So now there's more stuff out there that you can use to build your product.”

He also discussed that because different software are more and more readily available, there is no longer a sizable lead time on producing VR or AR applications. Therefore, it is a lot easier for a retailer to contract a company to create a product product, and they no longer have to wait a year or two. It's available almost immediately.

Expert 2 felt that in the industrial and enterprise space, cost was a barrier, but furthermore, “the industry mentality is that if it ain't broke, don't fix it.” Therefore, if an industry space is presently successful, senior management, especially those that are

older and less technically savvy, may potentially be less likely to integrate this technology. New technology often is riddled with bugs, errors, and sometimes the hype is not worth the actual product, like Google Glass, for example. However, “this is the future and we better get ready for it.”

When Expert 2 elaborated on the cost barrier, he said that the most important thing is to convince management that XR is an investment. The cost may be high initially, but will eventually save money. He specifically reverted back to XR for training, and stated, “It used to be when a new employee joined a company, the first two years of everything that they did was training, training, training and they were not necessarily producing anything. Now, companies can't afford to train employees for one year or two years anymore. They need production, but sometimes it is difficult to find immediate expertise. So one thing AR is going to do is to help bridge that gap.” If it can be conveyed and globally accepted that XR for training is a financial benefit to a company, XR will skyrocket in popularity and become an essential part of almost any industry, not just retail.

4.5 Future of XR (Data mining, wearables, and standardization)

When it comes to the future of XR, both individuals expressed surety the technology would become a mainstream necessity in all industries, not just in retail. However, both experts explored this topic from different perspectives. Since Expert 1 is involved with designing XR products for retailers, he took this question as a means of exploring what the future of XR creation will be instead of how it will help to sell products.

Specifically, he talked about the standardization of XR applications, and how XR will follow the same trends as most technological concepts before it.

“Ultimately, if you look at any form or any facet of the massive global concept that is the technology industry, you'll find that they kind of all follow the same path. They initially start with the concept of some sort of product or service

within the technology, which then gets refined and produced by individuals, and that tends to be quite fragmented. Then what happens is the necessity of that product is in place.”

He followed by describing the computer itself. He explained that during the 1970s, different PC manufacturers had different electronic components with their own unique designs. While that was great initially, the aim became then to refine and simplify these different products because there was no ability to grow when everyone was developing separately. Eventually, companies look for the most flexible component of all of those different facets, and “that gets focused on and merged with other smaller components. Then eventually what you end up with is companies like Microsoft, Apple or IBM, the main big companies that produce these individual product sets, and they're all compatible with themselves.” Therefore, “standardization becomes the name of the game. In any aspect of the technology industry, that happens every single time.”

He continued to describe other examples of major players in the game development industry, and how they are all essentially groupings of what were originally much smaller companies, an example of this standardization. Therefore, he felt when it comes to XR in retail, the same thing will happen. At the moment, there are many different components being developed in house or developed by specific contractors to produce applications that provide XR experiences to retailers and their customers. However, in the future, the industry will look to standardize and simplify. There will be a collection of “large standardised XR experiences that we can then essentially just kind of pull from and create our own different versions of which are able to be integrated within any retail experience, which is just another way of being able to empower the user because everything becomes super simple and it's more accessible to the non-tech savvy.”

Expert 2 had multiple different views on this topic. He felt the most immediate advances with XR would be in the AR arena because the hardware required belongs to almost all citizens in developed countries: the cell phone. He described the cell

phone as a vessel for augmented reality, and that it would bring industry to the next level. He said this would happen soon as well, and that the catalyst was the Covid 19 epidemic. "With people being isolated and having to stay indoors more, AR is really going to be huge as a result of the current economic and world crisis. AR is a quick and very elegant fix to the current situation." He continued by discussing how it has helped tech experts travel virtually, not physically to different plants around the globe during the quarantine, and how it also enables employees to train from home using specific applications.

After discussing the future of training with AR applications and its imminent growth, he made two further predictions about what lies ahead with XR technology: advances in both wearables and data mining.

With regards to wearables, he felt that Google Glass was ahead of its time, and that was why it was originally unsuccessful. However, "now with 5G technology and powerful bandwidth in terms of cellular data, we all have a supercomputer in our mobile devices...the technology is all there and it's a matter of companies piecing it together and then society accepting it, but they will."

He then discussed data mining, and what the shopping experience will look like in the future. Since all people have metadata attached to them, companies can currently use this information to learn about what the consumer wants and needs. He described an interesting futuristic scenario, similar to the movie *Minority Report*, where a consumer's metadata drives everything experience while shopping.

"When a company looks up consumer X, they know how consumer X likes to shop at a store. Consumer X likes green and prefers leather over faux. However, currently market research and data analytics shows that 60 percent of people prefer the red and blue over green, and therefore red and blue is going to be in the front of the store. However, that store is not going to capture consumer X's eye with any of the marketing flash if they only have red and blue in the window. How does the store reach consumer X, who is only 5

percent of the population that likes green? The answer is XR tied in with medidata. Whether it be through an XR app and GPS tracker on your phone, or a XR display in store, as soon as consumer X walks in through that door, everything's going to appear green. It's going to be the next level of spam mail.”

This vision of the future is quite plausible, and while it may mean convenience for shoppers, it also means less privacy. He continued by discussing how brick and mortar stores are struggling, and this may be a fix. By creating unique shopping experiences at a store, it may pull consumers out from behind their screens and into their retail space. On the other hand, it may go the other direction, and stores may go virtual. He questioned the desirability to even go to a mall anymore, especially with deterrents like a global pandemic, mass shootings, etc. Instead, “mixed reality, augmented reality, and virtual reality has the potential to turn your bedroom into Macy's.”

While both experts discussed different visions on an XR inundated future, they both agreed on one thing. XR is the future, and it is important for companies to start buying in and preparing for it to become a mainstream necessity for any retail business.

5. Conclusions

In this study, I set out to discover how XR technologies have and will impact the retail industry. As mentioned earlier, there is a lack of academic research done on this specific topic, which was one of the reasons it interested me. What this paper has uncovered, however, is how XR in retail is a multifaceted, broad subject which could be broken down into much more specific topics. These could include studies on the individual categories of XR technologies on retail, how different members of the retail supply chain utilize different XR technologies, future innovations in the XR sector, etc. Even though academic research on this specific topic is limited, there is a plethora of research on the individual topics within the larger research question, which makes this subject rich with potential. The largest obstacle encountered in this study was the global Coronavirus pandemic, which resulted in an inability to attend several conferences that were scheduled. It also made recruitment of interviewees challenging. This study would benefit from further research and attendance at more events in order to draw conclusions from a larger data pool. However, significant commonalities derived from triangulation of the three data collection methods indicate conclusions drawn from this study are sound.

5.1 Identifying and understanding different XR technologies and the study of individuals who have experience with these applications

In conducting research, this paper reviewed existing literature on the subject of XR technologies through databases, scholarly journals, books articles, websites and industry reports. Through these methods, this paper was able to identify and understand the different XR technologies that exist, which are virtual reality, augmented reality and mixed reality. In order to study individuals who have experience in the implementation and development of XR technologies in retail, an initial goal of this paper, two semi-structured interviews were conducted with industry professionals paired with attendance at several industry events, conferences or meetups. These events provided access to presentations, networking, demos and discussions. Since XR technology is rapidly evolving, like most technical

applications, it was important to not only look at former research, but to engage with the people who are presently involved in this technical revolution.

5.2 How XR technologies impact business in areas such as sales, client, marketing, etc

After conducting qualitative research and coding and theming data collected through the three means of investigation, this study revealed several recurring ideas. It found that the customer experience was a major selling point for the benefits of XR in the retail end of the supply chain. The literature review discussed the importance of providing purchasers with added value propositions and optimize the customer experience with unique, individualized virtual ‘touchpoints’. This was validated by Expert 1, with his discussions of using VR in luxury sales, where the sale involves a single item being sold at a high price point for an individual customer, and this customer wants a unique, tailored experience. Expert 2 also confirmed the importance of providing improved customer experiences, and discussed how data mining could be used to make unique, XR in-store experience catered to individuals, drawing them to the physical store and not just the online shop. Finally, Allen Wixted drove this point home with a discussion on how his AR furniture application creates unique customer experiences that promote consumer satisfaction and less returns.

5.3 XR as a solution to problem areas in the retail sector, success and failures of past integration, and industry market readiness

This study aimed to identify problem areas in the retail industry, and how XR technologies have been or could be used as a solution. It also looked to understand the market readiness for XR technologies in the retail industry and examined past and current successes and failures of immersive integration.

It became clear that market readiness is a major factor involving the success of XR technologies in the retail sector. The literature review and both expert interviews indicated that it remains an obstacle, but the hurdle is lowering its height. Specific

hindrances to market readiness included insufficient tech management, cost barriers, and an aging workforce. This became evident in the literature review and Expert 2's discussion of the potential but ultimate failure of Google Glass, a technology that was ahead of its time. Google Glass set the stage for companies to question an XR investment. However, times have changed, and according to Expert 1's evaluation of current XR applications, they have become significantly upgraded over the last few years, including improvements in cost, usability, integration, and availability, areas in which counter the above mentioned obstacles. Ease of accessibility and bulkiness of equipment was another major obstacle that arose through this paper's research into VR and MR technologies in the retail sector. Accessibility, according to Expert 1, has been significantly improved in the last few years with the simplification of XR applications and the ease and speed in which business can obtain these technologies. However, it was evident through the literature review, presenters Darragh O'Brien and Cordula Hansen, and Experts 1 and 2 that a challenge for VR and XR is the requirement of proprietary technology.

While proprietary technology will continue to remain an obstacle for certain products on the retail side of the supply chain, experts and presenters alike found there were significant benefits to using this technology in other supply chain areas, like manufacturing, and also as a means of training employees to ultimately create and sell products better. XR can provide solutions to problem areas of training access and expenses, and while there are currently XR applications being used for these purposes, the expectation is that due to the current global Coronavirus pandemic, specifically noted by Expert 2, the use of XR will become more and more prevalent. Furthermore, XR technologies can solve the problem of insufficient customer experience and satisfaction. Both experts expressed ways in which immersive tech can be utilized to improve the customer experience. Also, Alan Wixted specifically referenced the current problem area of costly product returns, something which the integration of his AR furniture placement application solved.

5.4 XR technologies currently being implemented in the retail industry

This study also looked at exploring how XR technologies are currently being implemented in the retail industry. An examination of this research indicated different categories of XR technologies are more likely to find mainstream successes in different areas of the retail supply chain. Darragh O'Brien simplified it best. The uses for XR technologies can fall under three categories: consumer, industrial, and enterprise applications. AR is most commonly used in consumer applications to improve the customer experience due to client access to tablets or smartphones. Examples of successful integration include L'Oreal's Genius App at branded stores and the Hema retail outlets in China. Because VR and XR require proprietary technologies, these applications are more prevalent in both industrial and enterprise applications. In the industrial setting, they can be used for the purposes of prototyping and remote assistance, while enterprise applications might include enterprise training and behavioral analysis. This was all validated through Expert 2's discussion of VR and MR as a means of training and prototyping and L'Oreal's VR lab and store prototypes. It was also confirmed with Expert 1's discussion of VR as a hardware heavyweight while AR is more successful on the retail floor due to consumer accessibility.

5.5 Potential future impacts of XR technologies in retail

This research identified a clear outline of the past and current XR landscape. So what lies ahead for the future of XR in the retail industry? While Expert 2 suggested that it would either save or destroy brick and mortars, David Roth, CEO of The Store WPP, claimed that if Chinese retail is any indicator, brick and mortars and e-commerce will only thrive if their entire supply chain becomes digitized and they learn to coexist through the use of XR technologies. Brick and mortars can become venues in which the consumer is not solely arriving to buy a product, but they are also leaving the comfort of their homes to partake in a unique customer experience, something that XR technologies can and will provide. Research also suggests that XR technologies will become increasingly mainstream over the next few years with

creation of standardized, seamlessly integratable applications that benefit industrial, enterprise, and consumers in the diverse and complicated retail industry supply chain. There will be advancements in everything from training applications, eye tracking for behavioural analyses, data mining, cell phone apps, virtual environments and more. While in the past, companies that did not jump on the XR 'bandwagon' managed to survive till now, but eventually, these applications will become part of mainstream customer experience and training programs. As people become more familiar with XR technologies, they will become integrated into more and more of our everyday lives. Therefore, consumers will be expecting these applications to be a part of every customer experience, and trainees will anticipate a well-developed XR training program. Utilizing XR will become the new status quo, and in order to survive, the retail sector will need to embrace the evolution.

6. Appendix

6.1 Interview Questionnaire

INTERVIEW QUESTIONNAIRE FOR PARTICIPANTS

TRINITY COLLEGE DUBLIN

In the interviews, open-ended questions will be asked and issues raised will be followed up on. The following questions are therefore indicative only.

1. What is your name, and where do you work?
2. Can you describe your educational and professional background?
3. What is your experience with XR Technologies?
4. Can you describe any XR projects you have implemented in the past?
 - a. What was the project's purpose/goals?
 - b. What was the outcome?
 - i. Do you have any statistical data to support these outcomes?
 - c. Were there any complications?
5. Can you describe any current XR projects you are working on?
 - a. What is the project's purpose/goals?
 - b. Can you describe the research that was used to develop this project?
 - c. Do you foresee any complications?
 - d. Can you describe market readiness for this project?
6. Can you describe your vision of the future for XR Technologies in retail
7. In your opinion, which XR technology is most relevant to the retail industry, now and in the future?
 - a. AR
 - b. VR
 - c. MR
8. Can you describe the different uses for XR technologies in retail - Customer experiences vs. client research and development of products and sales.

6.2 Ethics Committee Approval Email

TCD REC WebApp: The status of 'SCSS Ethics Application - XR in Retail' (748) has been updated by the Committee

rec-app-help@tchpc.tcd.ie <rec-app-help@tchpc.tcd.ie>
To: pittb@tcd.ie

14 April 2020 at 14:26

The status of 'SCSS Ethics Application - XR in Retail' has been updated by the Committee.

Title: 'SCSS Ethics Application - XR in Retail'
Applicant Name: Breanne Pitt
Submitted by: Breanne Pitt
Academic Supervisor: Nina Bresnihan
Application Number: 20200108

Result of the REC Meeting: Approved

The Feedback from the Committee is as follows:
All comments have been addressed - we wish you the best with your study.

The application can be viewed here:

https://webhost.tchpc.tcd.ie/research_ethics/?q=node/748

If amendments are required, please use the following link to edit the application and upload the changes:

https://webhost.tchpc.tcd.ie/research_ethics/?q=node/748/edit

6.3 References

Works Cited

- A. Alkhamisi and M. Monowar, "Rise of Augmented Reality: Current and Future Application Areas," *International Journal of Internet and Distributed Systems*, Vol. 1 No. 4, 2013, pp. 25-34. doi: 10.4236/ijids.2013.14005.
- Aguilar JGS, Aguilar IA. Interactions between human, computer and food. Food Nutr OA. 2019 Apr;2(2):116
- "Areas of Business Where XR Is Used Worldwide 2019." *Statista*, 28 Feb. 2020, www.statista.com/statistics/1099168/areas-of-business-where-xr-is-used/.
- Brakus, J. Joško, et al. "Brand Experience: What Is It? How Is It Measured? Does It Affect Loyalty?" *Journal of Marketing*, vol. 73, no. 3, 2009, pp. 52–68., doi:10.1509/jmkg.73.3.052.
- Chan, Rachel. "VR Use Cases Series: The Retail Game-Changer." *VR Blog*, 24 May 2018, blog.yulio.com/blog-vr-use-cases-retail.
- Çöltekin A. et al. (2020) Geospatial Information Visualization and Extended Reality Displays. In: Guo H., Goodchild M., Annoni A. (eds) *Manual of Digital Earth*. Springer, Singapore
https://link.springer.com/chapter/10.1007/978-981-32-9915-3_7
- CORREIA, Carolina Ferreira - Drivers of emotions and purchase intention in virtual supermarket setting: explore the rule of mental imagery, product involvement and presence [Online]. Lisbon: ISCTE-IUL, 2019. Master's dissertation.
[Consult. Day Month Year] Available at [www: <http://hdl.handle.net/10071/19006>](http://hdl.handle.net/10071/19006).
- Crum, Roy L., and Itzhak Goldberg. *Restructuring and Managing the Enterprise in Transition*. The World Bank, 1998.

- Dad, Aasim M, Davies, Barry J and Kear, Andrew (2016) 3D Virtual Worlds: Business and Learning Opportunities. *International Journal of Advanced Computer Science and Applications*, 7 (1). pp. 7-20. ISSN 2158107X
- Farfan, B. 2018. Definition, Types and Examples of Retail.
<https://www.thebalancesmb.com/what-is-retail-2892238>. Accessed on 15 February 2020.
- Fisher, Scott S., "Virtual Environments, Personal Simulation, & Telepresence" in *Virtual Reality: Theory, Practice and Promise*, S. Helsel and J.Roth, ed., Meckler Publishing, 1991. reprinted in *Ars Electronica: Facing the Future*, T. Druckrey, ed., MIT Press, 1999
- Flavián, Carlos, et al. "The Impact of Virtual, Augmented and Mixed Reality Technologies on the Customer Experience." *Journal of Business Research*, vol. 100, Oct. 2018, pp. 547–560., doi:10.1016/j.jbusres.2018.10.050.
- Javornik A. Augmented reality: Research agenda for studying the impact of its media characteristics on consumer behaviour. *Journal of Retailing and Consumer Services*. 2016;30:252-261
- Johnson, Carrie, et al. "Forrester's New Breakout Vendor Series: Stay On Top Of Disruptive Technology." *Forrester*, 14 July 2017,
go.forrester.com/blogs/16-05-11-forresters_new_breakout_vendor_series_stay_on_top_of_disruptive_technology/.
- Kumar, Gulshan, and Preeti Sharma. "Google Glasses Impediments." *International Advanced Research Journal in Science, Engineering and Technology*, vol. 1, no. 2, Oct. 2014, pp. 80–84.
- Lemon, Katherine N., and Peter C. Verhoef. "Understanding Customer Experience Throughout the Customer Journey." *Journal of Marketing*, vol. 80, no. 6, 2016, pp. 69–96., doi:10.1509/jm.15.0420.

- Lipow, Valerie. "Tech Trends in Retail." *Monster Career Advice*, 2020, www.monster.com/career-advice/article/retail-technology-trends.
- Mann, Manveer Kaur, et al. "A Multidisciplinary Examination of 3D Virtual Shopping Environments: Effects on Consumer Perceptual and Physiological Responses." *Ideas in Marketing: Finding the New and Polishing the Old*, 2014, pp. 752–755., doi:10.1007/978-3-319-10951-0_277.
- Mazuryk, Tomasz, and Michael Gervautz. *Virtual Reality - History, Applications, Technology and Future*. Institute of Computer Graphics Vienna University of Technology, Austria, 1999.
- Milgram, P. & Kishino, F. (1994). A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on information Systems*, 77(12)
- Milnes, Hilary "How L'Oreal Uses Virtual Reality to Make Internal Decisions at Its New York HQ." *Digiday*, 16 June 2017, digiday.com/marketing/loreal-uses-virtual-reality-make-internal-decisions-new-york-hq/.
- Mordor Intelligence. 2018. Retail Industry Trends, Growth - Segmented by Product (Food And Grocery, Apparel, Furniture, Consumer Electronics, Personal Care, Jewellery), Type of Store (Convenience Store, Specialty Retailer, Supermarket And Hypermarket, Internet Retailing, Discount Store), and Region - Growth, Trends and Forecast (2018 - 2023). <https://www.mordorintelligence.com/industry-reports/retail-industry>. Accessed on 28 December 2018.
- N. Badler, M. Hollick, J. Granieri: Real-Time Control of a Virtual Human Using Minimal Sensors. *Presence*, Vol. 2, No. 1, pp. 82-86 (1993)
- O'Brien, Darragh. "Darragh O'Brien - Pitch for VR in Consumer Behavioural Analysis." *XR in Retail*. XR in Retail - XR Dublin, 16 Oct. 2019, Dublin, Ireland.

Pickup, Oliver. "Google Glass Lessons: Why Businesses Must Look Past XR Hype." *Raconteur*, Raconteur Media Ltd., 6 Apr. 2020, www.raconteur.net/technology/google-glass-xr-hype.

Pope, Hannah. "Virtual and Augmented Reality in Libraries." *Library Technology Reports*, vol. 54, no. 6, 2018, pp. 1–25., doi:10.5860/ltr.54n6.

Reynoso, Javier. "Value Merchants: Demonstrating and Documenting Superior Value in Business Markets 2009 " James C. Anderson, Nirmalya Kumar, James A. Narus. Value Merchants: Demonstrating and Documenting Superior Value in Business Markets. Boston, MA: Harvard Business School Press 2007. , ISBN: 13: 978-1-4221-0335-7." *Journal of Service Management*, vol. 20, no. 5, 2009, pp. 580–583., doi:10.1108/09564230910995152.

Rossi, Ben. "The Five Key Technology Trends Businesses Must Embrace to Stay Ahead." *Information Age*, 20 Nov. 2019, www.information-age.com/five-key-technology-trends-businesses-must-embrace-stay-ahead-123460947/.

Roth, David. "The Digital Era of Retail." Adtower and Quividi - Engaging "Brand Conscious" Shoppers with DOOH- The Importance of Live Data in a Performance Marketing Era. Adtower and Quividi - Engaging "Brand Conscious" Shoppers with DOOH- The Importance of Live Data in a Performance Marketing Era, 3 Dec. 2019, Dublin, Ireland.

Soni, Aman Kumar. "The Difference between Augmented Reality, Virtual Reality and Mixed Reality." *Medium*, Medium, 1 Mar. 2019, www.medium.com/@shivsoni377/the-difference-between-augmented-reality-virtual-reality-and-mixed-reality-a028bdd81f9d

Speicher , Maximilian, et al. "What Is Mixed Reality?" *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19*, May 2019, pp. 1–15., doi:10.1145/3290605.

Sutherland, Ivan. (2001). The Ultimate Display. Proceedings of the IFIPS Congress 65(2):506-508. New York: IFIP. 2.

“Themes and Codes.” *University of Huddersfield*,
research.hud.ac.uk/research-subjects/human-health/template-analysis/technique/themes-and-codes/.

“Volvo Cars and Varjo Launch World-First Mixed Reality Application for Car Development.” *Press Release*, 29 May 2019,
www.media.volvocars.com/global/en-gb/media/pressreleases/253105/volvo-cars-and-varjo-launch-world-first-mixed-reality-application-for-car-development.

Wixted, Alan. “Alan Wixted - The Craftsman.” XR in Retail. XR in Retail - XR Dublin, 16 Oct. 2019, Dublin, Ireland.

Yuen, Steve & Yuen, Yin & Yaoyuneyong, Gallayanee & Johnson, Erik. (2011). Augmented Reality: An Overview and Five Directions for AR in Education. *Journal of Educational Technology Development and Exchange*. 119. 119-140. 10.18785/jetde.0401.10.