Enriching Retail Customer Experience Using Augmented Reality

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WWW.CBS.DK

ISSN 0906-6934

Print ISBN: **978-87-93956-76-6**
Online ISBN: **978-87-93956-77-3**

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PhD Series 33.2020

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1st edition 2020
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The CBS PhD School is an active and international research environment at Copenhagen Business School for PhD students working on theoretical and empirical research projects, including interdisciplinary ones, related to economics and the organisation and management of private businesses, as well as public and voluntary institutions, at business, industry and country level.

Acknowledgments

In early 2017, while I was the Chief Information Officer of Digital Banking and MobilePay at Danske Bank in Copenhagen, Prof. Stefan Henningsson and Prof. Jonas Hedman approached me for an interview on the digital transformation going on at the bank. This was for a Coursera course, and I had no idea where this was going at that time. After a couple of weeks, they asked if I had any team members who might be interested in an Industrial PhD program at CBS. I asked for more context for what this meant and then pondered. I was all alone in Copenhagen at that time (my family was in Chicago, and I had come to Denmark for this job) and wondered if I could enroll as a candidate.

I asked my leader, Jim Ditmore, at Danske Bank if he would support it, and he was surprised, saying that this would be a lot of hard work and long days. I like challenges and told him if the bank could sponsor me, I would like to take it on. Jim was able to secure sponsorship from Danske Bank. Then I got back to the Professors and told them I wanted to do a doctoral program. They were awesome, helping me with the pre-requisites, verifying my transcripts from many years ago (from India and the US), and validating that requirements were met. I joined in October 2017 to become a student again. I had a lot of interest in immersive technologies and wanted to understand how it could enable retail transformation. Little did I know that there would be a global pandemic, and AR would become an enabler.

While in Denmark, I worked with a couple of students - Mark Lohse and Philip Archibald - who were instrumental in gathering the data related to the case study with Louis Poulsen. While looking for other cases for AR in retail, I sent multiple introductory emails to different retailers; some responded saying they did not have anything yet. Then, Mr. Jesper Nielsen, the head of Personal Banking at Danske Bank, introduced me to an executive at Mastercard. This was a timely introduction as they were doing an AR implementation with Saks 5th Avenue in NYC. They agreed to provide me with information on their implementation of the AR solution.

I left the bank at the end of 2018 for an exciting opportunity to become the Chief Technology Officer at OneMain Financial in NYC in the US. I had to leave Denmark but did not want to give up on my PhD program. Prof. Michel Avital granted me the ability to continue the program as an International student. This was very helpful as I did not have to break what I was doing or continue at another University back in the US.

In early 2019, via my professional connections with Infosys, I managed to get a couple of very interesting cases, using AR to improve retail customer experience and with human-centered approaches. An investment of time was required to learn the approaches, participate in the interviews, and observe the co-creation and design thinking sessions. I needed to be away from work in my new job. My leader, the Chief Executive Officer, was fully supportive of this time needed for my research.

I would like to thank my supervisors, Prof. Stefan Henningsson, my primary supervisor, and Prof. Chee Wee Tan, my secondary supervisor, for their support throughout this journey. Stefan was instrumental in continually checking on my progress, providing me feedback on the content of my thesis, asking me to rewrite portions of the content for clarity, having me add more academic background, extending my thinking, as well as encouraging me. I would also like to thank the Professors and students from the WIP2 seminar, who provided valuable feedback. Their inputs were very useful, and though I had to transition from an article-based thesis to a monograph, which was a lot of work, it made complete sense. These professors have become great connections for me, and I am indebted to them for trusting my abilities to get this work completed.

Dr. Ganesan Keerthivasan of ZealStrat in CA, USA, and Mr. Michael Harboe of Virsabi, Copenhagen, Denmark were great sounding boards for sharing information related to the practical use of different AR displays.

The leadership and team members at Louis Poulsen, Mastercard, and Infosys were instrumental in providing me inputs via interviews and other documents, allowing me to visit and participate in some of their sessions, and validating my interpretations via email and phone.

All of this would not have been possible if not for the support of my family – my wife, kids, and both sets of parents - who allowed me to spend the weekends and weeknights for the last several months working on my case analysis and thesis writing. I know I did not do a lot of the housework due to my focused effort on the studies, and I will make sure to give back once this journey ends.

Abstract

This thesis investigates Augmented Reality (AR) as a technology with important implications for addressing and enhancing customer experiences in the retail industry. Technical inventions in devices such as mobile handsets, head-worn glasses, interactive mirrors, and a range of wearable devices have paved the ground for AR and other immersive technologies to spread rapidly into new contexts of use. In the retail domain, this inroad of AR happens at a time when the industry is subject to a significant transformation that involves changes to structures, processes, and roles and, ultimately, a fundamental shift in the competitive logic, from enabling an efficient transaction to the formation of holistic customer experiences. Positioning AR as part of this industry-level transformation, the thesis seeks to explain the relationship between AR and customer experiences as well as provide guidance for the design of AR solutions which will have a positive impact on such experiences.

The research employs an integrated customer experience framework to analyze the impact of the AR solution in two qualitative case studies, one based on a head-mounted device to enrich an in-shop experience, and the other based on a smartphone app to enrich a mobile experience. With this analysis, the thesis develops an explanatory model that connects AR solution characteristics to the production and perception of customer experiences, through nine distinct impact mechanisms.

Then, building on the explanatory model to articulate guidance for the design of AR solutions, the thesis argues the need to turn to human-centered approaches that can fit evolving technological possibilities to context-specific requirements for enhanced customer experiences. By analyzing two additional cases with a focus on the design process, the thesis specifies a human-centered approach and a set of actionable guidelines that cover how to effectively use human-centered approaches in the context of AR design for enhanced retail experiences.

The thesis documents the potentially transformative impact of AR on how customer experiences are created by retailers and perceived by consumers in retail. However, the analysis demonstrates that these effects require an AR design approach that considers the holistic customer experience. When seeking to leverage emergent technical possibilities, the use scenario must be relevant both to the actors involved in the production of the experience, and to the intended users who should perceive the experience positively.

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1 Introduction

The thought of a technologically reproduced "reality" is an idea that can be traced back to the roots of photography and movie making[1]. Rather than watching a picture from a distance, moviemakers wanted to accentuate emotional response by reproducing sensory stimuli that made the audience feel immersed. Early attempts included a train recorded to run straight into the audience, making viewers throw themselves to the ground, and the Sensorama experience by Morton Heilig to reproduce a motorcycle ride through a city[2]. These early explorations demonstrated the power of technologically produced immersive experiences to trigger an emotional response among users. They gave grounds for specific-purpose head-mounted devices such as Helig's "Telesphere Mask" and Ivan Sutherland's "The Ultimate Display," which would serve as a window to a virtual world.

Digitally-enabled Immersive Virtual Environments (IVEs) (Cahalane, Feller, and Finnegan, 2012a), popularized under the labels of Virtual Reality (VR) and Augmented Reality (AR), have over the last decade moved from avantgarde movie-making and experimental labs to becoming a phenomenon of significant societal impact. Previously prohibited by costs and technological limitations preventing any scale in adoption (Fox, Arena, and Bailenson, 2009), these immersive technologies have become cheaper, easier to use, and more mature (e.g., Cummings and Bailenson, 2016). It has pushed IVEs to a broader audience. VR is now claiming grounds in gaming and making inroads into areas such as healthcare, where surgeons undertake complex operations remotely (Shuhaiber, 2004), and in the construction industry to improve building design (Heydarian et al., 2015). However, because VR devices remain rather expensive and technologically constrained, use is typically delimited to specific niches, with developments still in experimental stages.

In contrast, AR is a technology more mature and ready for adoption at a commercial level (Appendix 2) that makes the transformative impact on society real[3]. AR, the focal technology in this thesis, is a real-time technology that merges digital elements with the environment so that the user perceives the elements as part of the real environment (Azuma et al., 2001). As a 3D visualization method, AR allows the user to examine an object from any viewpoint (Azuma, 1997). It is an efficient visualization method

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[1] For a historical overview, see for example, "History of Virtual Reality" by the Virtual Reality Society, https://www.vrs.org.uk/virtual-reality/history.html

[2] See, The Franklin Institute's overview of the historical account of immersive technology, https://www.fi.edu/virtual-reality/history-of-virtual-reality

[3] For example, Daniel Newman writes in a technology outlook article for Forbes Magazine, "AR Yes, VR (Still) No: I'm kind of starting to feel bad for virtual reality (VR) because it's so cool, but it just isn't feasible beyond gaming and highly specialized applications in today's marketplace—yet. Instead, augmented reality (AR)—VR's less sexy little brother— […] has found tons of use cases in enterprise workforce, training, meaning it's not just cool, it's useful." https://www.forbes.com/sites/danielnewman/2018/09/11/top-10-digital-transformation-trends-for-2019.

in application areas where real and virtual elements benefit the user. There is a need to enhance users' spatial perception in their shopping journeys and their interactions with products and services (Siltanen, 2012; Avery, Sandor, and Thomas, 2009).

Not least, inventions in mobile handset technology have made smartphones act as portable AR devices. Recent achievements to establish a WebAR (Web-based Augmented Reality) as a defacto standard have made it possible to produce AR experiences right in the smartphone browser without installing specific purpose software. Standards have enabled AR to make inroads into a wide range of application areas, with a shifting focus from consumption of the technology per se to how AR's new possibilities can enable new practices. Therefore, AR accounts for most investments in the IVE market and is predicted to grow into an $80 billion market by 2025 (Goldman Sachs, 2016).

AR is currently making substantial inroads in the retail industry (Bonetti et al., 2018; Javornik, 2016; McCormick et al., 2014), where actors in the retail sector are looking to tap into immersive capacities for new ways to interact with prospective customers. An illustrative case in point is Gap's "DressingRoom" app[4] that allows users to try out a dress on a virtual mirror, cutting down on the time and effort of going into a fitting room. With this app, shoppers can try outfits and pick the best fits for their sizes and tastes. Once customers enter their body measurements in the app, they will see a life-size mannequin wearing the clothing they intend to buy. If they like the style and fit, they can buy the clothing through the app.

Another illustrative example is how the custom-fit eyewear company, Topology Eyewear, seeks to reshape the eyewear industry with an app that combines AR with 3D scanning to help people design customized glasses that fit them precisely. Customers take a quick video selfie of themselves, select the frames they prefer, and finally fine-tune the frames' width, height, and alignment.

Retailers worldwide have been impacted and shut down for many months during the COVID-19 pandemic. Those using AR are enjoying a 19% spike in customer engagement, according to data from Vertebrae[5], and the customer conversion rate increases by 90% for customers engaging with AR versus those that don't. Consumers display a higher level of consideration as they make purchases online for items that they would typically go to a store to see, touch, and feel. Because of this, they are more open to trying newer experiences like 3D & AR that give them the confidence to buy by answering questions like "How big is it?"; "How does it look on me?" or "How does it look in my space?" and "What are the

[4] https://www.gapinc.com/en-us/articles/2017/01/gap-tests-new-virtual-dressing-room

[5] https://www.retailcustomerexperience.com/articles/why-retailers-should-embrace-augmented-reality-in-the-wake-of-covid-19/

details?" Another reason for increased consideration is that they definitely don't want to make a trip to the post office to process a return.

Importantly, even without the pandemic, this increasing use of AR is taking place at the same time as the retail industry is undergoing a significant transformation that implicates its structure, processes, technology, design, formats, and sizes. It has grown in sophistication, dynamism, vibrancy, and interactivity over the years (Bagdare, 2016). The retail industry accounted for $26.29 trillion in sales in 2019 (Statista, 2019), making it a significant part of the world economy (Limited, 2018). As the sector saw the birth of e-commerce, many retail businesses were closing down (Berman, 2019; Rigby, 2011) due to the abrupt growth of online retailers. Retailers felt the need to transition into online retail without dwelling on the dynamics of the transition and the business model. In the current times, retail is on the verge of transitioning again into the model of omnichannel retail (von Briel, 2018), which is defined in different ways by different authors (Lazaris and Vrechopoulos, 2014; Juaneda-Ayensa, Mosquera, and Sierra Murillo, 2016).

As a core component of retail transformation, the retail industry's competitive logic is increasingly characterized by competition on customer experiences. Customer experience is the *aggregate and cumulative customer perception created during learning about, acquiring, using, maintaining, and disposing of a product or service* (Carbone and Haeckel, 1994; Jain et al., 2017). An experience occurs when a firm intentionally engages individual customers in a way that creates a memorable event. Therefore, the "*organization needs to create a cohesive, authentic and sensory-stimulating total customer experience that resonates, pleases and differentiates an organization from the competition, to build an emotional connection with customers*" (Berry & Carbone, 2007, p. 26). In the retail industry, the last decade has witnessed a dramatic shift in competition from a traditional transaction focus to creating complete customer experiences (Jain et al., 2017; Sorescu et al., 2011). In 2010, 36% of companies competed based solely on customer experience, whereas in 2018, this number had increased to 89% (Gartner, 2018).

In recognition of this turn to experience-based competition, retailers seek to leverage AR in the various touchpoints in the customer's shopping journey. From interactive mirrors to navigation inside the store, to mobile AR apps when you are on the move or at home, retailers are using AR apps to transform the way we try, buy and use their products. AR impacts retailers as they look at the different digital and emerging technologies to drive transformation and innovation to better connect with their customers, affecting customer purchase decisions when shopping online or in physical stores (Grewal et al., 2017). AR can positively impact both the online and brick-and-mortar sectors in retail by enabling the interaction with virtual objects and by enhancing the shopping experience with capabilities offered by the internet (Gaioshko, 2014).

In academia, AR has been extensively studied since the 1990s (Carmigniani et al., 2011), giving rise to two distinct strands of cumulative knowledge building: research concerning the more technical nature of AR and research concerning potential uses of AR (Rouse et al., 2015). The first strand of research, which received extensive attention, particularly at the beginning of AR research, is mainly interested in AR's technological side (O'Mahony, 2015). In this strand, researchers investigate, for example, how to optimize the design of head-mounted displays (Caudell and Mizell, 1992), the use of fiducial markers for AR video tracking (Kato and Billinghurst, 1999), or methods for real-time object identification (Rekimoto, 1998).

The second, a more recent research strand, has begun using AR solutions in various application areas, including which aspects are of particular importance to users and how they adapt and respond to them within that area (Rouse et al., 2015). Overall, this research has shown that AR takes a very distinct form depending on its context of use. While the technological building blocks remain the same, an appreciation for the situation of use is critical to account for the potential impact of AR in a specific domain and how that impact can be effectively harnessed.

Specifically related to retail, previous research has focused broadly on experiments and applications for the clothing industry via virtual-fitting rooms (Lum, 2013), product 3D previews before making a purchasing or buying decision, enriching shopping experiences (Brody and Gottsman, 1999), and understanding ingredients of products (Lum, 2013). Another focus has been using AR as an effective marketing tool to enable a new form of visualization and interaction. In particular, AR can enhance brand recognition and empowers advertising campaigns (Lum, 2013). AR, in marketing campaigns, has been seen as a form of experiential marketing due to its use not only on a product/service but also on an entire experience created for customers (Yuan and Wu, 2008; Bulearca and Tamarjan, 2010). While the use of AR in retail and marketing is increasing, there are still several limitations preventing its mass adoption. Other studies of AR in retail have dealt with, for instance, the consumer adoption of smart in-store technology comparing different applications (Kim et al., 2016), or the presentation of a prototype of a shopping application to support healthy grocery shopping (Ahn et al., 2015). The awareness is low, and not every product can display the interactions (Eyuboglu, 2011).

In the extant literature, the primary AR devices investigated include mobile AR apps used in mobile commerce (Dacko, 2017) and smart mirrors used in in-store retail situations (Javornik, 2016). Among the retail types, clothing retail has received comparatively much attention (Poushneh, 2018), motivated by this retail segment's size in terms of turnover and the documented particularities of fitting clothing to body types.

In terms of research methods, initial work for its use in retail has been dominated by experimental settings. Experiment participants have been exposed to AR technologies in simulated environments investigating the technologies in isolation from any interfering use context (Bonetti et al., 2018). Another frequently employed research approach includes surveys targeting AR users to capture self-reported use behavior (Poushneh, 2018).

1.1 Research Gaps and Research Questions

AR in the retail context (see Chapter 3) is an emergent but rapidly growing topic in the literature. However, thus far, relatively little research has addressed AR from the perspective of the ongoing transformation of competition based on customer experiences. Instead, explanations of customers' use of AR are extensively framed within the Technology Acceptance Model (TAM) (Davis, 1989), suggesting that use will happen when retail customers find the AR technology easy to use and useful (Poushneh et al., 2017). In this context, extant research has further specified usefulness in the online shopping situation in terms of AR technology's capacities for telepresence, referring to its ability to reduce the spatial distance between customers and goods in online commerce (Schwartz, 2011). This reasoning line is closely linked to a view of retail competition based on price-quality transaction logic, rather than on the formation of customer experiences.

It has been suggested that AR has the potential to deliver compelling customer experiences in retail (Poushneh and Vasquez-Parraga, 2017). This argument has been made predominantly by extending technology acceptance models to include customers' stated attitudes towards the technology customer experience (Rese et al., 2014). Furthermore, research has also indicated that regardless of online or in-store use, the hedonic values (enjoyment, fun) closely related to customer experience formation are important variables in explaining AR adoption (Childers et al., 2001; Huang and Liao, 2014).

However, in extant research that has extensively employed surveys and experiments to investigate attitudes to and adoption of AR in retail (see Chapter 3), AR's potential impact on customer experience has largely been black-boxed. This has resulted in a limited understanding of the mechanisms by which AR can impact the customer experiences, and an associated limited understanding of how different technical attributes of the AR design and retail situations interact to trigger these mechanisms. Therefore, it has been suggested that a critical avenue to further the understanding of AR in retail is to address the implications of AR in terms of its effects on retailing, its integration within retailing, and the value it provides for customers (cf. Hagberg et al., 2017). This understanding will be needed to define which AR attributes will enhance customers' experiences (Poushneh and Vasquez-Parraga, 2017). It will affect the contexts in which customers are willing to use AR (Rauschnabel and Krey, 2017), and identify the potential values of AR that are possible to realize in practice.

Therefore, with the ambition to develop an explanatory understanding of the link between AR characteristics and the formation of customer experiences (Boneti et al., 2018), the first research question addressed in this thesis is:

RQ1: How does AR enrich the retail customer experience?

To answer this question, the thesis employs a customer experience perspective (Verhoef et al., 2009; Boneti et al., 2018) to analyze two qualitative cases of AR impacts within the retail industry. In one, an integrated AR solution was implemented by a group of collaborating organizations to enhance the customer experience for finding clothes, checking how they look, deciding on choices, and paying for them, using the integrated solution in Saks Fifth Avenue. In the other, Danish design company Louis Poulsen commissioned an AR app to visualize some of its lamps in prospective customers' intended use space. Building on the analysis of these two cases, the thesis develops an explanatory model in which nine impact mechanisms cover the potential impact AR has on retailers' production and consumers' perception of customer experiences. This explanatory model contributes to an enhanced understanding of how AR enriches customer experiences in retail via its impact mechanisms.

With the explanatory model that forms a link between AR and customer experiences as the basis for the answer to the first research question, this thesis then has a further ambition to contribute knowledge about the process of designing AR solutions that can impact customer experience.

The cases studied to explain how AR enriches retail customer experiences provided a number of reasons for why the users – both retailers and different types of customers should be engaged upfront to understand the need and format for AR in the customer shopping journey, what levels of information services and content the solution should provide, how it will work as well as protect privacy of the customers and security of information while giving the users ability to experience the products in different ways creating utilitarian and aesthetic value. The design of these solutions to enrich specific retail experiences can be achieved using human centered design approaches. These approaches are not without limitations (Bogers et al., 2010) because the understanding of what is needed and why differs based on experience and understanding for the different type of customers and retailers, their ability to provide requirements and insights as well as engage fully in the design of the solutions. The users engaged in the human centered design may negatively impact the outcomes or misinterpret what it can actually provide to enrich specific retail rxperiences. Still these approaches are needed to promote new technology solutions like AR solutions to help improve and overcome the current barriers to usage to meet specific needs.

Generally, the literature on AR has investigated and described the technological components of AR (formats and devices) relatively extensively. It has created a technological terminology and overview of technical design parameters that comprise a foundation for designing AR solutions. Furthermore, previous works on AR and retail have investigated cognitive dimensions of usability (e.g., Butler, 1996). In extension, they produced indicative advice on how to account for cognitive constraints in the AR design.

However, past research has focused more on investigating existing AR solutions than on the process by which they are formed in practice. In particular, little attention has been given to how these technological building blocks can come together to have desired impacts on customer experiences (Swan and Gabbard, 2005). The development of functionality and user interfaces for these interactions relies on users' prior knowledge and exploits their expectations and familiarity (Hofmeester and Wixon, 2010). The software that accompanies the new devices lacks cohesion, standard best practices, and detailed usability design. Interfaces and interaction techniques vary between apps and devices, and ultimately user experience suffers (Metz, 2013). It causes friction of use and engagement when the technology is implemented, because of unfamiliarity, lack of usable interfaces and features, or lack of alignment to the users' needs and interests. Although prior literature has studied some customer experience dimensions, no mutual agreement has emerged on understanding the impact on a more enriched or engaged customer experience (Vermeeren et al., 2010). Customer experience is a complex construct that encompasses a user's inner state, product characteristics, and context (Hassenzahl and Tractinsky, 2006) and varies across time (Law et al., 2009).

Therefore, considering the design as the process by which technological AR components are combined to impact the customer experience in a defined retail context positively, and with the ambition to engage users and their interactions in the design of the AR solution to satisfy the specific scenario where AR makes sense, the second research question addressed in this thesis is:

RQ2: How to design AR to enrich specific retail customer experiences?

To answer this research question, the thesis analyzes two additional cases where the process of designing AR to enrich customer experiences was in focus. In one, a co-creation approach is used with users to design an AR web app to address the challenge of finding products not readily on the in-store shelves, where the users can browse a catalog to find combinations of clothing they desire. In the other, a design thinking approach is used, developing a personalized, secure integrated smart mirror to reduce the fatigue of physically trying-on clothing and improve the store policies for returns. These cases are analyzed based on a framework covering the core principles of human-centered design, which involves users intensively in the design process (Karat, 1996). By implementing a human-centered approach, designers in the two cases embraced the cognitive and affective dimensions of customer experience, so AR's impact would enhance the retail customer experience (Alben, 1996). The underlying argument for human-centered design approaches is that AR is an emerging retail technology where the user interaction is crucial to its success. Having users participating and engaged upfront to iteratively co-design and co-develop the AR solution to fulfill a particular need will result in feasible and viable solutions to enhance the underlying retail customer experience. Approaches from human-centered design to co-design and co-develop with users enable the development of right-fit solutions to enhance particular retail customer experiences (Alben, 1996).

This thesis is based on the general argument that a human-centered approach is suitable to fit retailer and user perspectives on valuable customer experiences with the rapidly evolving technological possibilities and constraints of AR technology. It uses the studied cases of the AR design process to articulate a human-centered approach mainly targeted to the design of AR to enrich customer experiences in retail. The approach provides actionable guidance for retailers and AR developers to design AR to achieve the desired impact.

Taken together, the two interrelated research contributions position AR within the ongoing transformation of retail towards competition based on customer experiences. The research findings have important implications for the academic understanding of AR within the retail context. They also have practical implications for retail businesses to develop effective AR-based solutions to enrich the overall retail customer experience along the different touchpoints of the customer's shopping journey.

1.2 Organization of the Thesis

The remainder of the thesis is structured as follows:

Chapter 2 provides a view of how the research was conducted and includes research design and philosophical perspectives. It gives context for how the case studies were selected, which cases, and why. The chapter details methods of how and what data was collected and how the data was analyzed. It includes multiple qualitative analysis methods – interviews, social media, public announcements, focus groups, observations, co-creation, and design thinking approaches.

Chapter 3 sets the foundation by explaining the phenomenon of AR and its characteristics, retail and digital technologies, and their impact on the ongoing retail transformation. It summarizes AR's current uses in retail, how they are set up, what is available, and gaps that emerge in how AR could address and enhance the retail customer experience. It introduces a theoretical framework incorporating AR characteristics and dimensions for organizational and customer level to form the basis for the research studies. (The extant review for AR use in retail is built on a literature review of AR in IS that was published in Hoffma et al., (2018))[6].

Chapter 4 presents the Saks and Louis Poulsen cases as an explanatory study[7] within the theoretical framework to understand how AR impacts the retail customer experience, as described in Chapter 2. The cases are analyzed individually and then contrasted. Each case is analyzed using the theoretical framework and collectively summarized to explain how AR can address and enrich retail customer experience. This chapter develops a conceptual explanatory model to explain how AR impact mechanisms can affect the retailer's strategy and the consumer's perceptions of customer experience in retail.

Chapter 5 transitions from the technology-centric view of AR to a human-centered view of AR by presenting the limitations from the impact study where AR is a technology solution, and introduces Human-Centered Design, with the process, principles, and commonly used human-centered approaches. The human-centered approaches conceptual model is developed. It encompasses enriching the retailer's customer experience management strategy and customer perception of the experience. The model is used to analyze the AR design study comprising of two cases in Chapter 6.

Chapter 6 presents the ICETS case[8] using a co-creation approach, followed by the Infosys case utilizing the Design Thinking human-centered approach. These cases are analyzed individually using the model from Chapter 5 and then contrasted to provide relevance for engaging users to identify the context,

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[6] Appendix 1 **Paper 1:** C. C. Hofma, S. Henningsson, and N. Vaidyanathan, "Immersive Virtual Environments in Information Systems Research: A Review of Objects and Approaches," in Academy of Management Proceedings, 2018, vol. 2018, no. 1, p. 13932: Academy of Management Briarcliff Manor, NY 10510

[7] Appendix 1 **Paper 2:** Vaidyanathan N. (2020) ICVARS 2020: Proceedings of the 2020 4th International Conference on Virtual and Augmented Reality Simulations, February 2020 Pages 27–34, https://doi.org/10.1145/3385378.3385383

Appendix 1 **Paper 3:** Henningsson, Stefan; Vaidyanathan, Nageswaran; Archibald, Philip; and Lohse, Mark, "Augmented Reality and Customer Experiences in Retail: A Case Study" (2020). AMCIS 2020 Proceedings. 18. https://aisel.aisnet.org/amcis2020/strategic_uses_it/strategic_uses_it/18

[8] Appendix 1 **Paper 4:** Vaidyanathan N. (2020) Augmented Reality Technologies Selection Using the Task-Technology Fit Model – A Study with ICETS. In: Rocha Á., Adeli H., Reis L., Costanzo S., Orovic I., Moreira F. (eds) Trends and Innovations in Information Systems and Technologies. WorldCIST 2020. Advances in Intelligent Systems and Computing, vol 1160. Springer, Cham. https://doi.org/10.1007/978-3-030-45691-7_61

requirements, design, and development of AR solutions to enrich specific retail customer experiences. It concludes with a proposed framework for steps to be used for AR design with the users.

Chapter 7 discusses the findings and the models from the impact study and the design study to contribute to extant literature from an academic and a practitioner standpoint. It answers the underlying RQs posed at the outset of the studies. There are three significant contributions to theoretical knowledge. The first contribution is evaluated as a form of theory for describing and explaining (using the explanatory model from Chapter 4). The second contribution is evaluated according to the criteria of theory for design and action (using the model from Chapter 5). The third contribution is the framework for the steps to design AR solutions with users (Chapter 6). The chapter highlights implications for AR technology designers and retail managers, describes limitations, and concludes with a future research agenda to demonstrate how the research can be extended or probed. This emerging technology plays an important role in the retail domain, highlighted by AR's emerging trends.

Chapter 8 concludes the thesis with an overall perspective of the research's intent and learnings. It provides a view into the future for how this emerging technology should continue to be studied for its role in transforming the retail domain.

2 Research Methodology

The chapter details the research methodology. It provides a rationale for the underlying research philosophy and paradigm used in the research. It details the choice of qualitative case studies and the iterative process for how the research was conducted. The chapter then describes the literature reviews conducted to understand extant research for AR in IS, use of AR in retail using a multi-displinary approach, and how AR impacts retail customer experience. The cases chosen to study AR's impact and the design of AR on the retail customer experience are discussed. For each selected case, the data collection and data analysis methods are then detailed. The evaluation of the contribution concludes the chapter.

2.1 Overall Research Design

Research paradigm

This research adopts a functionalist paradigm that contains both an objectivist and a regulatory dimension (Saunders et al., 2009). The objectivism dimension represents the position that social phenomena and meanings are independent of external social actors (Ibid). The functionalist paradigm's regulatory dimension deals with why a phenomenon occurs and tries to explain this phenomenon (Ibid) rationally. The problem-oriented approach to this paradigm is the reason for adopting it. Questions are asked in this research to clarify how does AR characteristics enrich the retail customer experience and how to design an AR solution that can enrich specific aspects of the retail customer experience and thereby create value for the customers and the retailers.

The research philosophy of interpretivism will be reflected throughout the thesis by interpreting how AR characteristics can enrich the retail customer experience. By its nature, this is subjective, based on how the consumers perceive the experience and what the retailers intend to achieve via their customer experience management strategies. The interpretive view allows for the interpretation of insights gathered from research done amongst human beings rather than objects. These human beings are seen as having different opinions and understandings of the same "reality" (Ibid). Besides, interpretivism is often looked upon as highly relevant for business and management issues. Insights gathered from primary and secondary data will be interpreted to explain the effects of AR characteristics on the retail customer experience (Ibid). Lastly, interpretivism emphasizes qualitative data rather than quantitative data.

The choice of qualitative case studies

Three key reasons made the qualitative case study approach suitable to address the research questions stated in the introductory chapter. First, was to focus on understanding the nature of the research issues rather than on the number of observed characteristics (Strauss and Corbin, 1994) by interpreting and contextualizing meanings from people's beliefs and practices in terms of how the use of AR affected their retail experience in the different retail settings (Denzin and Lincoln, 2011b). Second, it provided an opportunity to gain an in-depth holistic view of the research problem and facilitate describing, understanding, and explaining a research problem or situation (Baxter and Jack, 2008; Tellis, 1997a, 1997b). Third, it allowed for human-centered design and explanatory focus (Hyde, 2000; Yin, 2009), based on single or multiple cases. The focus is on a contemporary phenomenon within a real-life context, like the effect of AR in retail settings on the retailer's customer experience initiatives and on the customer's perceptions of the experience (Yin, 2009).

The research design is the logic that links the research purpose and questions to the processes for empirical data collection and data analysis, to make conclusions drawn from the data (Bloomberg and Volpe, 2008; Rowley, 2002; Yin, 2009). It implies or relies on the chosen research paradigm (Creswell, 2009). The sum of these decisions results in the case study protocol that ensures uniformity in research projects where data is collected in multiple locations over an extended period (Maimbo and Pervan, 2005).

One part of the work focused on AR and its characteristics as the unit of analysis to understand how AR addresses the retail customer experience (refer to Chapter 3). Two cases explore the different aspects of AR's deployment from how it affects online versus in-store retail, based on various devices and settings, its characteristics and limitations, and how these have implications for the different elements of the retail customer experience.

In addition, two subsequent cases focused on the AR design process as the unit of analysis. This research drew a human-centered (Macguire, 2001) approach to guide the design of AR solutions that enhances specific aspects of the retail customer experience. Here, the unit of analysis is the design process. The human-centered approach was used to understand how the participants could better grasp what the solution provides and whether it could enhance a specific retail customer experience element. The research design where a case study has formed grounds for extracting design-oriented knowledge has been applied elsewhere, resulting in "how to" contributions of importance to practice (see, for example, Markus et al., 2002).

The nature of this research's purpose and its prospective contributions assumes qualitative data being used (Yin, 1994). Based on quantitative data, it would be possible to isolate which characteristics of AR affect retail experience elements. It would give little insight into what makes the features mutually dependent and how retailers could influence the dependency, which is one of this research's purposes. The extant research of how AR can enhance retail experiences, as presented in Chapter 3, has not reached the maturity level or scale required to construct the hypothetical relations that a quantitative research approach would require. The limited knowledge of AR characteristics' impact on the retail customer experiences enforces a research approach, which includes attributes of an impact and design-based research using a flexible design approach. The choice between fixed design or flexible design is dependent on prior awareness and the possibility of stating potential relationships between dependent and independent variables (Robson, 2002). It provides a rationale for why qualitative research makes sense. It should be stressed that qualitative data tries to make sense of a real-world phenomenon using available means. This current research, drawing on George and Bennet (2004), takes the position that case studies benefit from pluralism in gathering techniques and sources and should use the means available to shed light on the phenomenon being studied. Qualitative research produces a holistic understanding of rich, contextual, and generally unstructured, non-numeric data (Mason, 2002) by engaging in conversations with subject matter experts and participants in a natural setting (Creswell, 2009).

The research process

The research process suggests progress where a preliminary understanding from a theoretical standpoint of the current state and research issues were determined based on existing literature. It is then extended by case studies to address different aspects of the underlying research to address the research gaps the thesis attempts to close via an impact and a design focus. The disposition is useful in outlining how the case study and its contributions provide final research contributions. It is iterative, as the theoretical framing was based on existing reasoning and outcomes and was used to gather empirical data and analysis. Iterative cycles of empirical and theoretical phases are considered appropriate when the objective is to develop an understanding of a theoretically immature domain (Alvesson and Sköldberg, 1994; Dubé and Paré, 2003; Mays and Pope, 1995; Miles and Huberman, 1994; Yin, 1994). Using a theoretical framework based on the awareness of prior research on the subject is essential for capturing relevant data while doing studies, as it creates the foundation for analytical generalization in case-studies (Yin, 2003). A literature study was carried out to develop a tentative framework (see Chapter 3). Darke et al. (1998) suggest that the use of the case study in research is useful in newer, less well-developed research areas, particularly where examining the context and the dynamics of a situation are important.

AR is still emerging, and its use in retail is focused on specific areas. For this reason, an iterative process is required for this research to understand what is available in the extant literature and to explain the existing research. The key phases of the research process are depicted below (Figure 1).

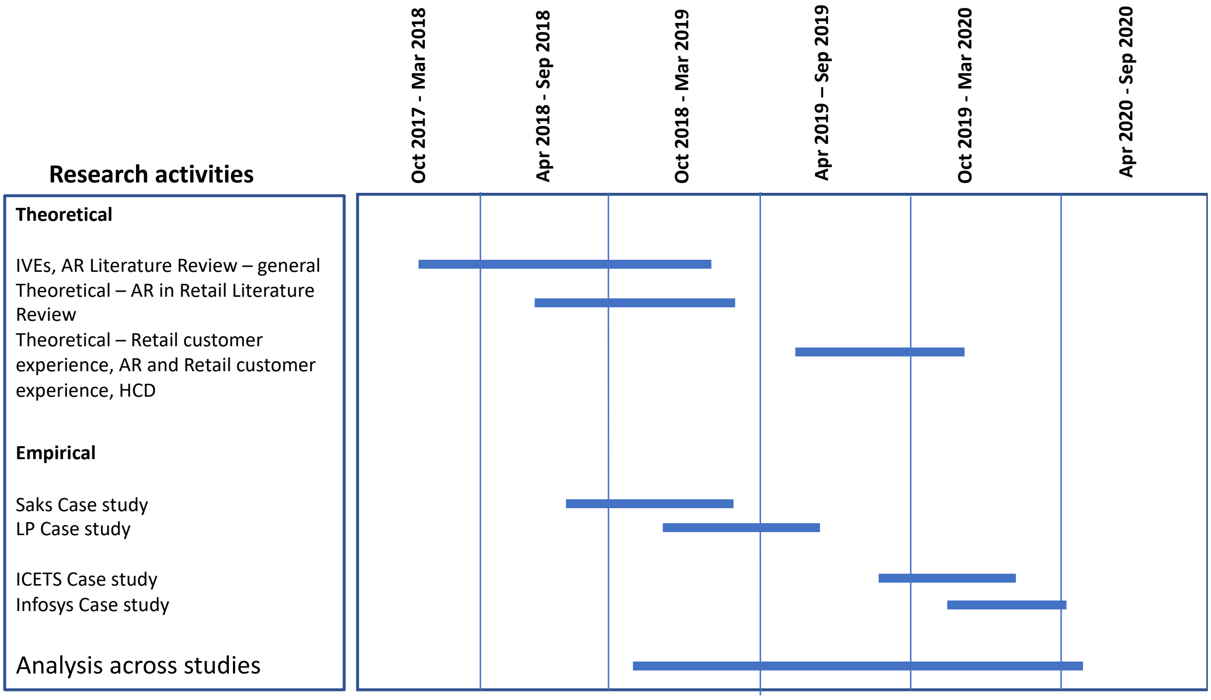

Figure 1. An iterative approach to the research

The iterations were based on the different research activities built upon one another as more theory was needed to support the underlying cases. It also made sense if the case analysis findings indicated the need to understand the underlying theory differently or if it was determined that new theoretical frameworks, models, or approaches were required.

The initial focus was to understand the existing literature for IVEs and AR, where it played a role in the different domains and what it was used for (Appendix Paper 1 - Hofma et al., 2018). It was followed by a formal and systematic review of uses of AR in retail, how they were set up, usage areas, and understanding key insights from the studies (Chapter 3). From these systematic reviews, key research gaps were identified and formed, based on the research questions (Chapter 1). The case study approach was used to answer these research questions. The cases selected and the rationale for selection are discussed in later sections.

The literature review provided a good understanding of what is extant in IS and the secondary data sources for the phenomenon of AR, its types and characteristics, and its use in the retail context.

2.2 Literature Review Method

Immersive Virtual Environments (IVEs) review[9]

Literature reviews were conducted to understand the phenomenon of IVEs. The reviews studied the types of IVEs, including where IVE has been used and in what way. The method used was limited to highly ranked journals and conferences, which is the basket of eight and the highest-ranked conferences of AIS: ICIS, AMCIS, PACIS, and ECIS (Webster and Watson, 2002; Vom Brocke et al., 2009). The scope was further narrowed by focusing on peer-reviewed material only, excluding material such as research in progress, papers, books, and popular articles. The articles were found by searching SCOPUS, Google Scholar, and the AIS library, using the following keywords and search operators: "augmented realit*" OR "mixed realit*" OR "virtual realit*" OR "virtual environment*" OR "immersive virtual environment*" OR "virtual world*" OR "3D" OR "3-D" OR "CAD" OR "computer-aided design*".

The search for keywords was restricted to the title and/or abstract, which resulted in 183 articles. Next, articles published before 2007 were excluded, resulting in 153 articles. 2007 was chosen as the cut-off point because this was the year when IS scholars started to publish articles on IVEs after the initial media "hype" in 2006 (Wasko et al., 2011; Cahalane, Feller, and Finnegan, 2012b). Furthermore, thirty-two articles were removed as they had limited relevance to the topic, i.e., papers on 3D-printing or papers that briefly mention 3D. It resulted in 120 articles that were chosen for further review.

The literature was copied into an excel sheet and was inspired by Webster and Watsons' description of a concept matrix (Webster and Watson, 2002). The coding was done over several iterations. During the first iteration, it was decided to identify the research approach of each article, which includes: the data analysis, data type, theoretical perspectives, and lastly, the level of study and thematic discourse. If possible, these dimensions were identified from the abstract, but they came from reading the introduction and methods section for most articles. After the first iteration, additional relevant dimensions relating to the question were appropriate and subsequently coded for. These dimensions are technology, context, and actor. The technology dimension refers to the type of technology being studied and referred to when defining the immersion. The context refers to the context in which the study was situated. Lastly, the actor category was defined as the primary actor observed in the respective articles.

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[9] Appendix 1 **Paper 1:** C. C. Hofma, S. Henningsson, and N. Vaidyanathan, "Immersive Virtual Environments in Information Systems Research: A Review of Objects and Approaches," in Academy of Management Proceedings, 2018, vol. 2018, no. 1, p. 13932: Academy of Management Briarcliff Manor, NY 10510

AR in retail context review

This review was conducted to understand how the research in AR in retail has evolved. It included research areas, understanding the data analysis and theoretical methods used, how data was collected, types of devices and displays used in the different papers, the extent of user interaction, how the senses were augmented, and learnings, limitations, and opportunities for ongoing research.

To understand the IS extant literature for AR in retail, a keyword search was done across the key publishers/journals/papers available in the CBS library database and Google Scholar from 2001 through 2018. The search was conducted using key text strings that included:

- Must contain AR or Augmented Reality and retail (shopping, shop, format were variants for retail)
- Application area in retail
- type of research method
- type of data collected (qualitative or quantitative)
- experimental tasks and environments
- type of experiment (pilot, formal, field, heuristic, or case study)
- senses augmented (visual, haptic, olfactory, etc.)
- user interaction – experience, engagement, values – hedonic, enjoyment, utilitarian
- type of display used (handheld, head-mounted display, desktop, etc.).

The keyword search yielded 86 papers (I left out virtual worlds, emerging tech in retail, and domain agnostic AR regarding retail). Google Forms was used to extract the information, which was then transferred to an Excel spreadsheet for data cleaning, manipulation, and filtering.

Although this was done systematically, there are some limitations to this review. The first involves using the CBS database and Google Scholar searches. Using such a database has the advantage of covering a wide range of publication venues and topics. However, it is possible that this missed publication venues and papers that should have been included. Second, although the search terms used seems intuitive, there may have been papers that did not use "Augmented Reality" or AR and retail as the primary search strings when describing an AR experience in retail. For example, some papers may have used the term "Mixed Reality" or "Artificial Reality" or other words. In particular, because citations are accumulated over time, it is quite likely that I missed some papers that may soon prove influential.

The retail customer experience and theoretical frameworks, models, concepts

This review was conducted to understand the retail customer experience: how it is explained, measured, and its context, using underlying frameworks, models, theories, and concepts, primarily in the retailing and consumer journals.

To understand the IS extant literature for retail experience, a keyword search was done across the key publishers/journals/papers available in the CBS library database and Google Scholar. The investigation was conducted using key text strings that included:

- Must contain 'retail customer experience' or 'retailing experience' or 'shopping experience' or 'retail journey' or 'customer journey management'
- Must contain the words' concept', 'framework', 'model'
- Store environment set-up, formats – online, in-store, mobile, multi-channel, omnichannel, atmospherics
- User interaction – experience, engagement, purchase, quality

The keyword search yielded 14 papers. Google Forms was used to extract the information, and then it was transferred to an Excel spreadsheet for data cleaning, manipulation, and filtering.

Although this was done systematically, there are some limitations to this review. Using the CBS database and Google Scholar searches covers a wide range of publication venues and topics. It is, however, likely that I missed publication venues and papers that should have been included. There might have been variations of the search strings I used and therefore missed some publications. In particular, because citations are accumulated over time, it is possible that I missed some papers that may soon prove influential.

2.3 Primary Data Collection Methods for the Impact and Design studies

The primary data collection techniques were qualitative in nature and comprised of semi-structured interviews. In the ICETS case qualitative surveys were used to understand the diversity of views from the team for what AR devices were used for what purpose. The specific semi-structured interviews cconducted are covered in the specific sections below for each case. The qualitative survey conducted is also spelled out in the ICETS case data collection section. Other primary data collection methods used were observations, focus groups specific to the ICETS case, as well as human centered approach sessions for co-creation in the ICETS case and design thinking for the Infosys case and are detailed in Chapter 5 and Chapter 6.

2.3.1 Semi-structured Interviews

Sewell (1998) defines interviews in qualitative research as "attempts to understand the world from the subject's point of view, to unfold the meaning of peoples' experiences, to uncover their lived world before scientific explanations." The qualitative interview is central to data collection (Gill et al., 2008). However, for the information obtained to be more authentic, it is critical that the researcher creates a good connection with the source.

A semi-structured interview is an outline of topics and questions prepared (Stuckey, 2013) but have no rigid adherence. The impact of these interviews is based on how the interviewee responds to the question or topics or mode in which it was conducted. Although there is a set of guiding questions usually via an interview guide, the response of the subject provides the flexibility to pose more enhanced questions than the initially drafted ones. This notion is upheld by scholars who state that semi-structured in-depth interviews are the sole source of information for qualitative researchers (DiCicco-Bloom and Crabtree, 2006) and an ideal data collection mechanism for qualitative studies.

This research used semi-structured interviews and their implementation was dependent on how the interviewee responds to the question or topics laid across by me. Although there was a set of guiding questions, the response of the subject provided me the flexibility to pose more enhanced questions than the initially drafted ones. For the cases, I did individual and group interviews based on availability and the nature of information sought (DiCicco-Bloom and Crabtree, 2006). The participants were provided with the much-needed flexibility of explaining issues based on how well they know them. It allowed me to interject where necessary and ensure that the subject understood the topic or question under scrutiny.

Different techniques were used, which included face to face (Doyle, 2005), telephone, skype, and e-mail interviews. For my cases I used these techniques based on the availability of the interviewees, their preferences, geographical location as well as to validate the interpretation of data collected previously (Opdenakker, 2006). Each of these techniques also had drawbacks based on the knowledge and state of the interviewees, their focused attention, length of time, clarification opportunities and how they responded to face to face versus skype, telephone or email (Doyle, 2005). The list of interviewees were determined based on the type of information and depth of responses desired as well as who were provided by the company where the case was being conducted. This was done via providing the context of the topic and the desired detail via the introductory letter to the contact in the companies that were part of the cases studies. A non-disclosure document was signed upfront to include confidentiality and informed consent (Corti, Day and Backhouse, 2000; Orb, Eisenhauer and Wynaden, 2001).

The outputs from each of these semi-structured interviews in each case was transcribed and then the content was validated with the contact for that case to ensure accuracy and validity of the interpretation. The specificities of these interviews are laid out in the cases studies for impact and design studies.

2.3.2 Qualitative Survey

Groves et al. (2004, p.4) define survey as "The survey is a systematic method for gathering information from (a sample of) entities for the purpose of constructing quantitative descriptors of the attributes of the larger population of which the entities are members." The qualitative type of survey does not aim at establishing frequencies, means or other parameters but at determining the diversity of some topic of interest within a given population. This type of survey does not count the number of people with the same characteristic (value of variable) but it establishes the meaningful variation (relevant dimensions and values) within that population (Jansen, 2010). Qualitative survey is the study of diversity (not distribution) in a population. In my case study, I used the qualitative survey to understand from the ICETS team how they propose usage of the different AR devices for different purposes and whether there were specific categories and themes in terms of the responses received. Thee responses from the qualitative survey was used to formulate the interview guide for the semi-structured interviews.

The initial interview with the head of ICETS provided the inputs to use a pre-structured survey, where the diversity to be studied was defined beforehand based on the skills and roles of the people in the population and the aim of the descriptive survey was to identify which of the predefined AR devices and its characteristics are stated empirically by the population to provide for further data collection and coding to analyse the case.

2.4 Coding in the data analysis for the Impact and Design studies

Coding was the method of data analysis used in each case studied based on the transcribed data from the semi-structured interviews, the textual data from secondary data sources, survey text responses as well as from the observations of focus groups. The data analysis sections under each of the cases for both the Impact and Design studies show the examples of coding done to determine the arguments or narratives used to analyse the case using the constructs from the underlying theoretical framework and models used in these studies.

Coding in its most basic form is the simple operation of identifying segments of meaning in the primary data collected and transcribed and labelling them with a code, which can be defined as “a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data” (Saldaña 2015: 3). In my studies, the basic coding approach of the copy-and-paste function in Excel was used to copy portions of text or images from the transcribed documents into new documents. This process created an inventory of data (cf. Saldaña 2015, Miles, Huberman, and Saldana 2013) to be able to acquire insights into the data by revisiting the data collected as well as missing pieces to tie data analysis together. By sorting the data into labelled segments, it enabled quicker access and re-looks.

The research questions were used as the background for how the data is labelled initially and to ensure its relevancy as well as dimensions for comparing responses from the data collected. Coding allows for transparency in tying the conclusions to the labelled data themes (cf. Guba and Lincoln, 1994; Elo et al., 2014). It allows for a focus on the applicability and meaning of the work to practitioners in many approaches to qualitative research (Kvale, 1995; Bochner, 2018). Coding is an important step in moving from the raw data to the findings, as well as being a means to maintain coherence between the objective and the results. It is a way to ensure that the questions asked are the questions that have been answered. It is interactive (Charmaz, 2014) as the codes are created as a means to understand the phenomenon and/or participants and their perspectives. This view is particularly prominent in the literature on grounded theory, where the research is not restricted by preconceived codes but understand codes as emerging inductively from interpreting meanings in the collected data.

In my studies, codes were developed by initially using phrases or terms from the transcribed documents based on what the interviewees said. The inductive approach using grounded theory is relevant when doing an exploratory study or when no theoretical concepts are immediately available to help you grasp the phenomenon being studied. Working systematically with coding allowed for the interpretations of the empirical material (Gioia, Corley, and Hamilton, 2013). In each of the cases, multiple initial open codes were determined (Charmaz, 2014). These codes, post the initial labelling across the two studies were coded iteratively which higher-level categories created from the initial code list using axial coding (Gioia, Corley, and Hamilton, 2013). This process helped in defining categories and then selectively coding these as themes.

The higher-level categories and themes, helped determine the narratives and arguments to explain the constructs of the framework and models used in the studies. Memos were used as ongoing reflections during coding concerning the codes, the phenomenon, the informants and their interrelations to help keep track of the labeling, categorization and themes to help with bridging the distinctions between coding, analysis and results. The data collection and coding exercises were done in parallel, and the memo was a great tool that can both inform subsequent data collection and lead to richer explanations in the analysis later on mapping specific statements from the interviewees to how the construct was explained using the theme of the code determined.

The individual sections for data analysis for each case shows a representation of the Exce tables produced after a series of coding the underlying data collected for that case or cases for both the impact and design studies.

2.5 AR Impact Study

The AR impact study was framed by an initial theoretical framework, developed by reviewing the AR literature to determine key characteristics of AR solutions, combined with an integrated framework covering the aspects of customer experience. The role of the two cases in this part of the research was to identify various ways by which AR solutions could impact the retail customer experiences.

2.5.1 Case selection criteria

The state of knowledge for AR in retail and understanding how the AR characteristics enriched the retail customer experience was the key motivator for the AR impact case study choice. This outline provided the rationale for selecting cases that would provide empirical outcomes and the data needed. To ensure relevance to answer the research questions, it was necessary to find comparable cases (Eisenhardt, 1989) in different retail formats using other AR devices (Seawright and Gerring, 2008), and meeting three critical criteria. First, the retailer had an investment in AR to provide a differentiated experience to the retail customers. Second, the AR solution was ready for commercial use and would not create negative perceptions. Third, the AR characteristics in the retail setting allowed the customers to interact with it. Both the retailer and consumer perspectives on the customer experience should be observable.

The cases were to be identified based on the research issues and gaps and required researching retailers engaged in this emerging technology and using it in different settings with different AR devices and formats. These case studies had to provide a more substantial base for theory-building (Yin, 1984). Moreover, the various studies should provide simultaneous maximization or minimization of differences and similarities of data. This is vital for discovering categories and relating their theoretical properties for further developing the emergent theory (Glaser and Strauss, 1967). The research questions indicate a cross-case analysis. Therefore, the case design should facilitate studying the phenomenon and drawing similarities across the comparative cases. The design followed was predominantly sequential, with one case following the preliminary analysis of the other. The advantage of this sequential approach is that the selection of each case and some of the issues examined can be informed by puzzles identified in earlier cases (Vaus, 2006).

Two similar yet comparable cases were identified in different retail settings and chosen to confirm the theoretical model for how AR characteristics can enrich the retail experience based on specific organizational and customer-level impacts. Similar cases representing the population will provide the most robust basis for generalization of the findings and contributions (Seawright and Gerring, 2008). The retailers where the case studies were conducted were selected to demonstrate the relevance and potential for AR, both in-store and online, and how existing the retail customer experience could be enriched by leveraging the AR characteristics

2.5.2 Short case descriptions

Saks Case

The Saks case was selected based on several criteria. It provided context to understand the role of AR in in-store retail, given that, to date, most of the AR research in retail referred to using AR online. The AR characteristics examined in this case included the type of device used, in-store format, integration of value adding services, level of information provided, interactivity, and the role of AR in a luxury retail clothing store. The retail format of Saks 5th Avenue was the basis for the retail experience elements examined in this case. Components included selecting products, try-on's of branded clothing based on product detail, searching for products in different aisles, standing in lines for making a purchase, and the delivery of purchased clothes. The integrated smart glasses used in this study included four partners – Mastercard that orchestrated the solution and integrated the authentication to its digital wallet, ODG that develop the smartglasses, Qualcomm that developed the iris authentication, and the retailer, Saks 5th Avenue, where the solution was installed. This case provided an opportunity to analyze how an integrated AR with value-added services impacted the retailer experience and the customer's shopping journey. The Saks case identified the need for more similar case studies to understand whether users engaged with other AR solutions differently and whether online versus in-store experiences made a difference. It also highlighted how the type of retail, in this case, a high-end retail clothing store, might impact the use of AR.

Louis Poulsen (LP) Case

To further understand the impact of AR for retail experience and compare and contrast to the first case, another case was searched for. This case analyzed how the retail experience may be affected in terms of customers making decisions from their own homes for real-life usage, using a mobile app that was not integrated with other services or applications

The Louis Poulsen case was chosen as it provided a different perspective from the Saks case in terms of how AR affects retail customer experiences for making product selections and enhancing their buying decisions from their own homes. The case extended the Saks case findings regarding how AR characteristics affected retail experience and showcased how the AR characteristics addressed elements such as store environments and store policies. This case provided a context for how different AR devices and modes could impact the retail customer experiences differently, depending on how and where they are offered and experienced, and while not being integrated to other services or applications.

2.5.3 Data collection

In the two impact cases, data collection followed the general principle of seeking an in-depth understanding of the cases. Given available empirical sources, multiple viewpoints were sought whenever possible to achieve this. Also, to the extent possible, data was collected for triangulation, validating factual claims.

Saks Case

The different questions and interviews were developed and conducted depending on the AR characteristics and the customer experience from organizational and customer standpoints.

Table 1 summarizes the data collection, comprised of primary and secondary data sources, including face to face interviews, online/video interviews, emails, feedback, and clarifications with the Mastercard Labs leaders, and YouTube videos provided by Mastercard on example cases, supplemented by Annual Reports. Press Releases available publicly and reports published in the media were used to inspire and complement data collection. Quotations found in publicly available articles were used to contextualize the customer experience and AR characteristics provided by this integrated AR solution studied at Saks 5th Avenue (Yin, 2003).

Table 1. Sources for data collection in the Saks case

Role	Data Collection method
Mastercard Labs Practice Lead	Primary interview, feedback on write-up, email inquiries
Senior Account Manager, Mastercard	Primary interview, facilitating data collection
Global Head, R&D Mastercard Labs, Dublin	Interview, quotation provided
Executive Vice President, Digital Partnerships, Mastercard	Quotations - publicly available
Executive Vice President, Digital Payments and Labs, Mastercard	Quotations - publicly available
Vice President, HEadworn, ODG	Quotations - publicly available
Active review of ODG smartglasses	Quotations - publicly available
Founder and CEO, ODG	Quotations - publicly available
Director, Product Management, Qualcomm Technologies	Quotations - publicly available
Mastercard and ODG (Press briefings)	Links provided
Mastercard (Media reports)	Links provided
Mastercard (YouTube videos)	Links provided
Mastercard (Annual reports)	Links provided

Semi-structured interviews

The interview guide (Appendix 5) and case protocol (Appendix 6) were designed around the research questions, and the theoretical framework from Chapter 3 guided the interview questions (Section 2.3.1). The interview guide contained a list of questions and topic areas covered in the interview with Mastercard. However, these were not read verbatim or in order but served more as an aide-mémoire. "Usually, the interviewer will have a prepared set of questions, but these are only used as a guide, and departures from the guidelines are not seen as a problem but are often encouraged" – Silverman (2009, p. 194). I could add additional questions about an unexpected but relevant area that emerged, and sections that didn't apply to the participant could be negated. Semi-structured interviews were conducted, using the face-to-face method to allow participants to easily clarify their answers or ask for questions to be elaborated (Lavrakas, 2008). Legard, Keegan, and Ward (2003, p. 138) note that "Although a good in-depth interview will appear naturalistic, it will bear little resemblance to an everyday conversation." Contacts were established early, and meetings were scheduled in advance for these interviews.

These interviews were conducted with people who had different roles concerning this Mastercard AR solution. The interviews complemented the other data provided like YouTube videos, annual reports, and press briefings to provide contextual and technological understanding and triangulate findings from interviews. The interviews were conversational, but with a charter to cover the theoretical framework (Chapter 3).

Mastercard Labs Practice Lead: A face-to-face interview with the practice lead of Mastercard Labs, who was engaged in developing the integrated AR solution, was critical. The goal was to understand the role of Mastercard Labs, its involvement in immersive technologies, the solution's intention, the integration methodologies, the companies involved, what worked and what did not, and why a high-end retail store was selected for the in-store retail setting.

Senior Account Manager, Mastercard: This was my initial contact when I expressed interest in a case study related to AR. At that time, Mastercard Labs was working with three other companies to build an integrated AR solution to be tested in-store at Saks 5th Avenue in NYC. The Manager helped me understand the nature of the study and that it was being done to help understand how integrated services with AR could impact customer experience in-store, given that previous Mastercard immersive technology set-ups were using VR at that time.

Publicly available quotations: The Practice Lead provided links to different interviews and press releases that provided the context of the integrated AR solution as seen by the key executives of the participating companies, including Mastercard, ODG, and Qualcomm, and that were available in public domains.

- https://www.vi-mm.eu/2017/10/31/odg-mastercard-and-qualcomm-show-off-augmented-reality-shopping/
- https://www.pymnts.com/mastercard/2017/mastercard-showcases-augmented-reality-shopping-with-iris-authentication/
- https://venturebeat.com/2017/10/23/odg-mastercard-and-qualcomm-show-off-augmented-reality-shopping/
- https://www.etcentric.org/money2020-companies-partner-on-ar-shopping-prototype/

Other data was collected from various sources depending on the research focus, such as annual reports and financial statements, public records, newspapers, and social media (Maimbo and Pervan, 2005), minutes of meetings (Myers, 2009). This type of data collection was adopted in all the studies to augment the primary data collection[10].

Louis Poulsen Case

Different questions and interviews were developed and conducted depending on both AR characteristics and the customer experience from an organizational and customer standpoint. The following sub-sections will elaborate upon the different data methods depending on the stakeholders. Two Masters Degree students performed the data gathering and initial analysis as part of their thesis. I have used their research and re-interpreted the data collected for this thesis, using the theoretical framework developed from Chapter 3. The sections below are extracted from what was provided by these students.

Semi-structured interview with Louis Poulsen personnel and retailers

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[10] Mastercard provided a list of publicly available data and access to their annual report

- https://newsroom.mastercard.com/press-releases/mastercard-eyes-the-future-of-retail-with-augmented-reality-shopping-experience/
- https://www.businesswire.com/news/home/20171023005360/en/Mastercard-Eyes-Future-Retail-Augmented-Reality-Shopping
- https://www.youtube.com/watch?v=y7qa15inORc
- https://www.youtube.com/watch?v=zdCCZzQX27Q
- https://www.ezodproxy.com/mastercard/2018/ar/HTML1/tiles.htm

The interview guide and case protocol (Appendix 7) was designed around the research questions, and the theoretical framework for the studies guided the interview questions (section 2.3.1). All interviews for this impact study were based on semi-structured interviews conducted with experts to capture rich and descriptive data about the participants' feelings, perceptions, attitudes, and opinions. A predetermined set of questions was used to perform these interviews where themes from these questions could be used throughout all the interviews with LP personnel and retailers. The order of questions varied a lot depending on the conversational flow and which stakeholders were interviewed, with additional questions added to get the required information. Semi-structured interviews were conducted, using the face-to-face method to allow participants to quickly clarify their answers or ask for questions to be elaborated (Lavrakas, 2008). Contacts were established early, and meetings were scheduled in advance for these interviews.

For the semi-structured interviews, three different interest groups were interviewed to provide different perspectives on how AR characteristics could enrich the retail customer experience. These groups are LP personnel, retailers, and customers. Table 2 visualizes the various stakeholders interviewed. To adequately cover organizational and consumer sides, 14 interviews were conducted, with two representatives from LP, three retailers, and nine customers.

Table 2. Interviewees in the Louis Poulsen case

Role	Key topics
Director of Brand and Communications	Target Audience, AR Implementation, Customer Experience, Objective and Purpose
Visual Concept and Merchandising Manager	Simplifying Processes, Customer Experience and AR Usage
Head of Lighting Departmen, Illums Bolighus	Customer Experience, AR Usage and Customers
Head of the Lights Department, Johannes Fog	Customer Experience, AR Usage and Customers
Owner at Vestergaard Møbler	Customer Experience and AR Usage, Customers
Customer 1	Customer satisfaction, Brand Experience, Convenience and Customer engagement
Customer 2	Customer satisfaction, Brand Experience, Convenience and Customer engagement
Customer 3	Customer satisfaction, Brand Experience, Convenience and Customer engagement
Customer 4	Customer satisfaction, Brand Experience, Convenience and Customer engagement
Customer 5	Customer satisfaction, Brand Experience, Convenience and Customer engagement
Customer 6	Customer satisfaction, Brand Experience, Convenience and Customer engagement
Customer 7	Customer satisfaction, Brand Experience, Convenience and Customer engagement
Customer 8	Customer satisfaction, Brand Experience, Convenience and Customer engagement
Customer 9	Customer satisfaction, Brand Experience, Convenience and Customer engagement

The interviews were complemented with a visit to the designer's facility, Virsabi in Copenhagen, to provide contextual and technological understanding and triangulate interviews. The interviews were conversational, but with a charter to cover the theoretical framework (Chapter 3).

Louis Poulsen personnel

The interviews conducted with employees from LP were done to provide an overview of how AR technology can create value internally. We, therefore, interviewed the person who implemented the application and their Visual Concept and Merchandising Manager. Their perspectives on how AR can create value internally are of great importance to our research as it answers whether AR can internally generate LP value.

Director of Brand and Communications: We conducted a face-to-face interview with the director, who has been employed at LP for seven years, and who was the primary person behind implementing the AR application at LP. The interview with him provided background knowledge of why they chose to invest in AR technology, the investment goals, and what the future had in store for AR at LP.

Visual Concept and Merchandising Manager: The Manager was contacted to learn more about how he can work with this technology and where AR can support his work processes to create a better customer experience.

Retailers

There are some standard criteria as to why specific retailers were interviewed. Firstly, they must sell LP products in their stores. Secondly, LP is a premium brand within the lighting industry, which means not all lighting retailers have their products, hence narrowing the options for retailers that can be interviewed. Further, there is a geographical limitation for the selection of retailers for interviews. Lastly, there is only a limited number of retailers who fulfill the criteria above. Within this segment, a relatively large number of retailers were not interested in participating in an interview.

Owner at Vestergaard Møbler: The owner, a 2nd generation of furniture and lighting dealer, became the store owner one and a half years ago. His expertise in furniture and lights retailing, where he came highly recommended by LP, was necessary. Secondly, Vestergaard Møbler is one of the largest single stores selling lighting products in the Greater Copenhagen area, with many customers visiting every day. They have good knowledge of customer experience and how this application by LP can be used.

Head of Lighting Department: Another retailer we had a face-to-face interview with was the Head of Lighting, who works at Illums Bolighus in Copenhagen. The head has been in charge of the lighting department for more than ten years. One of the most important reasons for interviewing the head is that Illums Bolighus is the store in Denmark that sells the most LP products per square meter. The head's expertise, combined with the fact that they have the highest conversion rate, gives insights into how AR can increase customer experience. It is fair to assume that Illums Bolighus has a good idea about how to sell LP products, and it is therefore attractive for our research to examine where AR can be used in their processes.

Head of the Lights Department: The head in charge of the lighting department at Johannes Fog in Lyngby has been working for Johannes Fog for many years and has been the head of the lighting department for four years. They were interesting to interview as their store is slightly different from the 'usual' LP retailers in that they sell items from as low as 10 DKK up to 50.000 DKK. They did not have the same exclusivity as other retailers did. It produced some challenges regarding how they could advertise LP products due to some brand-restrictions, where LP did not want to be associated with low-end brands.

Semi-structured interview with customers

In the Saks study, no interviews were conducted directly with customers. On the other hand, this study uses semi-structured interviews with customers to directly examine whether or not the AR technology characteristics can enrich customers' retail experience. Here the semi-structured interviews were conducted using an experimental approach. LP exposed the participants to the AR application by LP, and they had a chance to play around with it in their natural surroundings. It is important to note that customers were interviewed in their own homes to measure the effect of AR better, as the intent of the application is to be used by customers within their own homes. Lastly, the participants were exposed to the same line of questioning, enabling a comparison of the answers to measure the effect of AR on the customer.

A non-probability technique was chosen to select the customer samples for this research. The sampling technique to determine the participants for the experiment-inspired semi-structured interview is the typical case sampling. The standard LP segment is in the late thirties, well educated, from wealthy households, and with a fifty-fifty gender distribution. Additionally, LP deepens the age group based on internal research as between 45 and 65 years old. Secondly, to provide the analysis with some depth and applicability, the samples must have purchased or considered purchasing an LP product.

Therefore, sample one contains three customer interviews with participants that meet the sampling requirements of being late thirties and above, well-educated, and from wealthy households. Additionally, there is an intense desire within LP to create an interest with a lower aged audience. Researchers were interested in addressing this audience to make the research more applicable. Hence, sample two contains six customer interviews from a lower age group than the typical LP segment but meets the requirement to consider buying an LP product.

2.5.4 Data analysis

The theoretical framework developed in Chapter 3 was used to structure the analysis based on the primary and secondary data collected in each case (Ebneyamini and Moghadam, 2018). Data analysis was "interpretive" in nature. To provide a broad framing for the interpretative inquiry, the theoretical customer experience framework was used "as a lens to interpret or unfold" (Sarker et al., 2018, p. 759) the cases being analyzed. This approach is consistent with Walsham (1995, p. 76), who recommends "the use of theory in the earlier stages of interpretive case studies …". While the use of an overarching theoretical framing could constrain the potential discoveries made during the empirical analysis, this approach's motivation would be the deliberate ambition to re-frame the current study of AR from a transactional view of retail. The goal was to shift to an exploration of the novel phenomenon within an explanatory logic of additional relevance for the retail industry using the framework's constructs. In the analysis, I took several measures to "preserve a considerable degree of openness to the field data, and a willingness to modify initial assumptions and theories" (Walsham, 1995, p. 76).

Each of the known aspects of how the AR characteristics and how customer experiences are produced and consumed became coding categories applied to the material. It was done to organize the data around the different ways AR characteristics could impact each of the customer experience production themes. Contextual elements of relevance were captured through inductively generated coding categories. Table 3 illustrates how the coding was done to extract the constructs from the cases studied.

Table 3. Elements of relevance using coding of values aligned to the coding categories and themes

Themes	Coding categories	Values - Saks Case	Values - LP Case
AR technology	Interactivity	weight, ease of wearing, comfort, battery life, heating,	online, mobile, connectivity,
	Quality of augmentation	quality of images, size, color, lighting, combinations	size, lighting, height, fit, quality of the 3D objects
	Information levels	search, compare, price, brand, privacy concerns	social-media, search, compare, touch, feel
	Integration	authentication, delivery, purchase, aisles, return	social-media, internal applications, intermediaries
Retailer / Organization	Degree of Transformation	control, decision making, in-charge, personalized	empowerment, control, decision making
	Interactions	digital, in-store, sales associates	digital, social-media, reviews, comments, meet retailers
	Customer Journeys	in-store, luxury brand, prime location, touch and feel	online, mobile, luxury brand, touch and feel
	Store set up	control, non-linear touchpoints, new experience	uncoupled touchpoints, non-linear
Customer	Customer expectations	interaction with store, taliking to other customers	social-media feedback, comments, interact with other customers
		shopping journey, decision making, interaction with AR	purchase decision, touchpoint navigation, retailer interaction
		weight of smart glasses, not for left handed people, no interactions	touch and feel, size and height, lighting, fit
		enjoyment, browsing, compare, aesthetic, fun	fun, combinations, browsing
	Personal characteristics	reason for shopping, hedonic, enjoyment, purchase, social status, price and brand sensitivity	demographic impacts, fit at home, touch and feel

I developed different excel spreadsheets to record and manage the data collected for each case, and a case study documents folder, a log, and electronic communication exchanges to cross-check and validate.

The data collected in each case was divided into data reduction, data display, and conclusion and verification. In the data reduction phase, the process included familiarizing, selecting, focusing, simplifying, abstracting, and transforming the raw data collected (Miles and Huberman, 1994) by transcribing the content of the interviews or the essence of the secondary data used in each of the cases.

The coding process (Corbin and Strauss, 1990; Oates, 2005) consisted of multiple steps (section 2.4). In the first step, open coding was employed where the qualitiative data from the semi-structured interview transcripts was read repeatedly to break it into discrete pieces of data. Each of these pieces of data was coded with a. descriptive label by interpreting the data based on its properties and ensuring similar data were labeled with the same code. This coded data was stored via tables in excel based on the theoretical framework constructs for AR characteristics and the retailer or organizational and customer constructs related to the retail customer experience – both static and dynamic (Chapter 3).

In the next step, axial coding was employed to find connections and relationships between the code such as context behind the data and consequences of the phenomena described by the interviewee. The codes were then aggregated and condensed into broder categories between the codes. The categories for each of these themes were determined from the data collected for overlapping or intersecting statements or descriptions of these themes. The values for each of these categories were determined based on how each category was described by the data. Some of the values of the coding categories under the AR Technology theme intersected with how retailer or organizations and customers experienced the technology.

These categories were then brought together as themes or an overarching category using selective coding that catptured the essence of a recurring data trend in the transcripts. Then identify connections between this theme and the rest of the codes and data to make sure there are connections that give rise to arguments in the cases studied and give rise to the narrative being described. The remaining categories and codes that did not have supporting robust data were removed. Ater that the transcripts were read again to code to these overarching codes or themes. The themes were AR Technology, Retailer or Organization and Customer.

Then the themes were organized appropriately, so it made sense to understand and extend the contributions from the cases being analyzed. The meaning of the participant's place via the primary data sources was then combined with secondary data sources (Creswell, 2009) to provide a substantive contribution or identify gaps. The themed data from the primary and secondary sources are matched to the theoretical framework for how the AR characteristics enrich the retail customer experience, described in Chapter 4.

The empirical evidence obtained via the primary and secondary data used in each of the cases analyzed was used to categorize the specific impacts of AR to each construct for the organization or retailer and the customer. These impacts coded as impact mechanisms for both the retailer and the customer as themes to document the impacts of the AR characteristics on each of the constructs for the retailer ‘s customer experience management and the consumer ‘s perception of customer experience. The impact mechanism determines the positive or negative impact of each of the characteristics of AR – information level, interactivity and quality of augmentation - on how the retailer’s customer experience management or the consumer’s perception of experience is affected. Table 4 below illustrates how the impact mechanisms were coded based on the impact categories.

Table 4. Coding AR Impact Mechanisms

Theme	Saks Impact Coding category	LP Impact Coding category	AR Impact mechanism
Retailer	Customized and secure experience	Increased control over contextual conditions/Customer empowerment of contextual conditions.	Personal and contextual control
	Retailer employee interactions replaced by digital interactions in-store with enhanced engagement.	Retailer employee interactions replaced by digital interactions.	Digital Interactions
	Addition of touchpoints, digitalization of touchpoints across shopping journey.	Addition of touchpoints, uncoupling of touchpoints.	Uncoupled digital touchpoints
	Redistributes the touchpoints from one actor to another digitally.	Redistributes the touchpoints from one actor to another.	Redistribution of touchpoints
Customer	Introduces self service in physical stores	Introduces new channels for customer-customer influence.	New channels
	Personalization could create privacy concerns with digitized shopping journey	Personalizing of experience and potentially new customer demographics.	Personalization
	Alters and makes less predictable the sequence of events - hedonic versus aesthetic or utilitarian reasons	Alters and makes less predictable the sequence of events.	Shopping journey events
	Possibility of new experience low's without retailer or producer awareness.	Possibility of new experience low's without retailer or producer awareness.	New experience
	Enjoyment and hedonic experiences while shopping	New possibilities to entertain customer during a wait.	Varied purposes

The impact mechanisms were used to develop the conceptual model in Chapter 4 of howAR impacts can enrich the retail customer experience for the two cases studied.

Uisng the process described in the preceding section, I coded, categorized and themed all the data from the transcripts of the semi-structured interviews as a single coder. The iterative nature of the case studies required me to re-code the data or parts of it based on the responses gathered from the interviewees of the two cases (Mackey and Gass, 2005). This iterative process created the rigor and validity of how the themes and coding categories were determined and how data values were aligned to them.

2.6 AR Design Study

The explanatory model of AR's impact on customer experiences in retail was the foundation for the subsequent work to address how AR can be designed to enhance the retail customer experience. In this part of the research, the explanatory model served as the initial justificatory knowledge (c.f. Gregor and Hevner, 2012). Observations in the work leading up to the explanatory model indicated that the developed AR solution did not definitively enrich the retail customer experience, even though it was technically advanced. Its design did not sufficiently include the requirements, needs, and considerations of different types of consumers. Therefore, the general proposition to turn towards human-centered approaches was introduced (see Chapter 5). The design study cases were used to evaluate applying a human-centered approach to fit a technical AR solution to the retailer and consumer needs and foster a greater understanding of employing human-centered design towards this end. The process follows the example of Markus et al. (2002) to extract practice-relevant design knowledge from a case, with the ambition to articulate guidance for how to achieve a defined desirable outcome.

2.6.1 Case selection criteria

The AR impact case studies indicated a gap in understanding how the AR solution was designed in the retail setting to enhance specific retail experiences using AR characteristics (Chapter 5). The argument was made that design needed to move from technology-centric exploration to human-centric design, focusing on enhancing the retail customer experiences. Overall, this broad argument is framed in human-centered approaches.

In selecting these cases, the overarching criteria were that they would instantiate some version of a human-centered approach. Furthermore, to derive from the case how human-centered design should be enacted, the cases needed to be use refined AR design approaches, and not just initial exploration. It was deemed essential that the cases could represent both a broad "best practice" from an extensive set of designs and an in-depth illustration of how an AR design process could work in this context. Finally, these cases had to be in different retail settings, using different human-centered approaches, with multiple types of customers, the retailer, and the designers of the technology solution participating in the design. Two cases that together met these criteria were the ICETS and Infosys[11] cases, presented below. In each of these cases, there were specific retail customer experience-related problem scenarios where the retailer wanted to use digital technology to address and improve the customer experience and address

[11] The AR design case studies were both conducted with Infosys – one with ICETS, and the other with Infosys Retail. The cases are thus labeled ICETS and Infosys to distinguish them

the retailer's customer experience management challenge. The customers represented different levels of knowledge of and engagement with the technology, and these cases were set in-store (Infosys) and in-store and online (ICETS). These conditions would aid understanding of the AR design using the human-centered approaches in different retail settings. The case design was to analyze these comparative cases, predominantly sequentially, with one case following the other's preliminary case analysis. This was done to understand what the subsequent case should provide for, which was not observable in the first case.

2.6.2 Short case descriptions

ICETS Case

ICETS is the center for emerging technologies and solutions at Infosys and used a human-centered approach to build AR solutions to enhance specific retail experiences. The company tracked the types of AR, their characteristics and limitations, and their usage in retail. Being a global player, ICETS had multiple different engagements. I used this case for two purposes. Firstly, to understand how ICETS determined the criteria for selecting AR solutions based on AR's technology design characteristics. Secondly, to understand the co-creation approach with an apparel retailer and two types of customers, who had different expectations and levels of familiarity with AR, to design of a specific AR solution for use in-store and online. This case substantiated the relevance of using human-centered approaches for this emerging technology to enhance retail experiences.

Given the size of Infosys and its global client base and investments in different technologies, I asked them whether they had a new engagement, using a different human-centered approach to develop an AR solution in a different retail setting. This was to help me understand the difference between methods and the applicability of human-centered approaches in different retail environments with other retail experience challenges. At that time, the retail domain of Infosys was approached by a luxury in-store retailer, Ralph Lauren, looking for an interactive solution to reduce returns and increase customer engagement for the products being offered.

Infosys Case

It was evident from the literature reviews of AR in retail that the studies conducted to date were based on having AR in place and then understanding how users engaged, experienced, or used AR in an experimental or proof of concept approach. They did not include the users upfront to design and develop AR to enhance the retail experience. A luxury retailer, Ralph Lauren, was very interested in developing an AR solution to enhance specific retail experiences related to how it could provide the customer the freedom to choose and try-on apparel while also extending interactions with store employees if needed.

This experience would help transform their branding for how they engaged customers in developing superior experience.

2.6.3 Data collection

ICETS Case

The ICETS case was conducted in the US. Data collection was primarily via semi-structured interviews, in person and over the phone. A qualitative survey was sent to team members to understand how they saw AR attributes and limitations. Secondary data collection was from annual reports, public interviews, YouTube videos, and other social media (Maimbo and Pervan, 2005) (Table 5). ICETS did not provide access to direct customer feedback, as that was not sharable. However, I could attend the co-creation sessions to observe and take notes. The response from the ICETS head on an AR design case using human-centered approaches was positive. This allowed me to have conversations on ICETS' scope and activity with AR, the partners they engaged with to build integrated solutions, and their capabilities to design different AR devices in varied retail settings.

The qualitative type of survey was used (section to determine the *diversity* of the use and charactersitics of the different AR displays available at ICETS within that team. This type of survey does not count the number of people with the same characteristic but it establishes the meaningful variation (relevant dimensions and values) within that group to understand what device is used for what purpose and why. (Jansen, 2010). A list of questions in a survey format (Mackey, Cooling, and Berrie, 1984) was then sent to 30 ICETS team members. ICETS provided overviews and answered questions on its partners, engagements, and capabilities to use for the case. Responses to the survey questions administered to their 30 engineering development and leadership staff were consolidated into themes using coding. The questions asked were informed by the underlying technology and the theoretical framework of the human-centered factors impacting the design and development of AR solutions.

Co-creation sessions

I attended the co-creation sessions (explained in Chapter 6) as an observer. This was to understand how the process worked, what the inputs were from the retailer and the customers, and how AR technology was selected to meet users' requirements and address the underlying problem use case. I was not provided access to engage with or have interviews with the retailer or the customer participants directly; however, I had access to the artifacts created and asked interview questions to ICETS.

Table 5. Sources of data collection for ICETS case

Source of data	Number of people	Data Collection Method
AVP, ICETS Head	1	email. Interview, validation of content
Head of XR Labs	1	Interview, quotations
Principal Product Architect	1	Survey
Senior Designer (XR)	4	Survey
Technical Lead (XR)	4	Survey
XR Developers	18	Survey
Principal Architect - Emerging Technologies and Innovation	1	Interview, survey
Press releases		Quotation, research tidbits
Media reports		Quotation, research tidbits
Youtube videos provided by Infosys		Research use cases

Semi-structured interviews

The responses from the qualitative surveys were helpful in creating the interview guide for the semi-structured interviews (section 2.3.1). The case protocol and interview guide to conduct these interviews (Appendix 8) were centered around considering the human factors in designing AR solutions for the different clients. Three semi-structured interviews were conducted with the leaders of ICETS to understand how ICETS used the human-centered approach with their clients.

AVP, ICETS Head: The interview with the AVP as the overall head of ICETS was to understand the digital technologies they were engaged in, how they assessed the retailer's digital maturity, what were the different ways they determined the right solutions, including AR, and to understand the roles and responsibilities of his organization. He was also accommodating in connecting me to the other interviewee, helping administer the survey, and validating the content that I produced.

Head of XR Labs, ICETS: The head sees things others don't, thanks to his 20-odd years working in the computer graphics field. He helped paint a better picture of augmented and virtual reality capabilities by showing how the technologies will impact consumers and professionals, how they'll buttress new and old industries, and what paths are necessary to get there.

Qualitative survey

The qualitative type of survey (Section 2.3.2) was used to determine the diversity of the different AR characteristics based on device type and use. This type of survey does not count the number of people with the same feature (value of a variable). Still, it establishes the meaningful variation (relevant dimensions and values) within that population using a pre-structured list of questions (Boyatzis, 1998).

The sample size for the survey was determined based on the degree of precision and differentiation in the ICETS group structure, ability to gain access to the named subjects in the team, the stratification of the subjects to get different viewpoints from their perspectives, and the ability to conform to the underlying theoretical framework (Appendix 9).

Other Sources: Data was collected from various sources like a press release, media reports, and social media content provided by ICETS, depending on the research focus needs (Maimbo and Pervan, 2005). This data collection was adopted in all the studies to augment the primary data collection[12].

Infosys Case

The Infosys case was conducted in the US. Data collection was primarily via interviews with their Human-Centered Design leader and Retail Technology leader to understand how they used human-centered approaches with the right actors to design and develop AR solutions to address specific retail customer experience needs. Interviews were done with an interview guide (re-used from the ICETS study).

Design thinking

I attended the Design Thinking (DT) workshop and engaged in the focus group interviews with the co-design and development participants using the DT approach (explained in Chapter 6). I was not provided access to engage with or have talks with the users directly; however, I had access to the artifacts created and asked interview questions to Infosys.

Semi-structured interviews

The interview guide to conduct these interviews (Appendix 8) was centered around considering the human factors in the design of AR solutions for the different clients. Two semi-structured interviews

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[12] The ICETS team provided the following additional data sources that were publicaly available:

- https://www.infosys.com/services/incubating-emerging-technologies.html https://www.infosys.com/newsroom/press-releases.html
- https://www.infosys.com/services/incubating-emerging-technologies/offerings/living-labs.html
- https://www.youtube.com/watch?v=V37c1sFaJzA
- https://youtu.be/6zFCqDDGXeU

were conducted with Infosys's leaders to understand how Infosys used the human-centered approach with their clients (section 2.3.1).

Head of Learning and Development, Infosys: The leader of the Design Thinking approach at Infosys was interviewed to provide a good understanding of how Infosys used the IDEO DT approach and modified it to ensure that human elements for design and development were used. The process included deciding the retailer's maturity in these techniques. It involved organizing workshops and content and setting up interviews to make the retailer aware of the AR technology and its characteristics and how it could help address the customer experience problem.

Retail Technology Leader, Infosys: The retail technology leader specifically focused on Next-Gen Technologies like AR, AI, etc. He noted how Infosys had realized the importance of DT workshops for a clear definition of the problem, solution options, and a clear roadmap with the right mix of technology and operational processes. AR is gaining more and more traction as companies are investing more in AR that is led by a well-structured DT approach. He also helped review the case content once the draft was completed.

Focus groups: I was an observer of this mode of data gathering. Focus groups were key for data gathering to draw upon respondents' attitudes, feelings, beliefs, experiences, and reactions in a way that would not be feasible using other methods, for example, observation, one-to-one interviewing, or questionnaire surveys. The Respondent-Moderator format was used, where one of the group participants takes the lead as a moderator. Having one of the participants lead the discussion is thought to impact the group's dynamics by influencing participants' answers, thereby increasing the chances of varied and more honest responses (Kamberelis and Dimitriadis, 2005). It was done to change the dynamics of the group and generate more varied responses. The focus group setting enabled me to gain a large amount of information in a short period. The right mix of the luxury retailer, Infosys, and a few of their customers at the initial stages facilitated the definition of the problem, the expectations, and how those expectations could be fulfilled (Appendix 10). The participants' varying inputs and explanations were organized into themes and used to drive the DT workshops (Appendix 11) to design the iterations needed to co-develop the AR solutions.

Observations: A type of naturalistic observation was used to observe participants in this case. It enabled me to map how participants engaged with Infosys to co-design, the questions they asked, and how they accepted the technology as retailers or customers. I conducted observations given that Infosys did not provide direct access to the retailer and the customers based on the case's specifics. During the Infosys focus group discussions, the primary data collection methods included notetaking and participant observation (Stewart, Shamdasani, and Rook, 2007).

2.6.4 Data analysis

The data analysis for each of the cases is described separately based on the type of the case and the specific research methods used outside of the semi-structured interviews. In the ICETS case, an AR technology selection based on questions answered as well as a co-creation human-centered approach is used to understand how to design AR with the users to enrich a specific retail customer experience use case. In the Infosys case, focus groups and a design thinking approach is used.

The AR design case study with ICETS and with Infosys was done to understand how participants could be engaged upfront to address the underlying retail experience issues from the retailer and the customer's viewpoints. It helped uncover the impact of human-centered design characteritics on the AR technology design to enrich the retail customer experience's specific use cases. It is essential to select the right AR devices and formats and understand the key characteristics needed to enhance the experience. The conceptual model from Chapter 5 was used to design AR to develop the intended solutions in both cases.

Data analysis was "interpretive" in nature given the data collection methods used in the AR design study. I developed different excel spreadsheets to record and manage the data collected for each case, and a case study documents folder, a log, and electronic communication exchanges to cross-check and validate. The data collected in each case was divided into data reduction, data display, and conclusion and verification. In the data reduction phase, the process included familiarizing, selecting, focusing, simplifying, abstracting, and transforming the raw data collected (Miles and Huberman, 1994) by transcribing the content of the interviews and the observations used in each of the cases. This data was then coded and themed (section 2.4) via tables in excel to draw the necessary verifications and conclusions.

In each case for the design study, the coding process (Corbin and Strauss, 1990; Oates, 2005) consisted of multiple steps. The process was conducted and documented as Excel tables for the different types of data collected and themed – for the qualitative survey responses, the semi-structured interview transcripts as well as from the observations of the focus groups, co-creation, and design thinking human-centered approaches. These code themes were used to analyze the individual cases on its own and together and to draw conclusions based on how they mapped to the constructs of the model used in the study.

In the first step, open coding was employed where the qualitiative data from the semi-structured interview transcripts was read repeatedly to break it into discrete pieces of data. Each of these pieces of data was coded with a. descriptive label by interpreting the data based on its properties and ensuring similar data were labeled with the same code. This coded data was stored via tables in excel based on the model constructs used for the design study.

In the next step, axial coding was employed to find connections and relationships between the code such as context behind the data and consequences of the phenomena described by the interviewee. The codes were then aggregated and condensed into broder categories between the codes. The categories for each of these themes were determined from the data collected for overlapping or intersecting statements or descriptions of these themes. The values for each of these categories were determined based on how each category was described by the data. These categories were then brought together as themes or an overarching category using selective coding that catptured the essence of a recurring data trend in the transcripts. Then identify connections between this theme and the rest of the codes and data to make sure there are connections that give rise to arguments in the cases studied and give rise to the narrative being described. The remaining categories and codes that did not have supporting robust data were removed.

Then the themes were organized appropriately, so it made sense to understand and extend the contributions from the cases being analyzed. The meaning of the participant's place via the primary data sources was then combined with secondary data sources (Creswell, 2009) to provide a substantive contribution or identify gaps. The themed data from the primary and secondary sources are matched to the conceptual model for how the human-centered approach could enrich specific retail customer experience, described in Chapter 6.

Uisng the process described in the preceding section, I coded, categorized and themed all the data from the transcripts of the semi-structured interviews as a single coder. The iterative nature of the case studies required me to re-code the data or parts of it based on the responses gathered from the interviewees of the two cases (Mackey and Gass, 2005). This iterative process created the rigor and validity of how the themes and coding categories were determined and how data values were aligned to them.

The meaning of the participant's place via the primary data sources was then combined with secondary data sources (Creswell, 2009) to provide a substantive contribution or to identify gaps.

ICETS Case

For Part 1 of the case, the ICETS data collected via the semi-structured interviews were themed, based on the AR technology designs offered by ICETS. The semi-structured interviews were transcribed and themed as Positioning, Type of technology, format, design characteristics, barriers and technology limitations. For each of these themes, coding categories and codes were determined (section 2.4) that were then used to format the questions for the qualitative survey (see Appendix 9). Table 6 illustrates the coding from the semi-structured interviews.

Table 6. Coding responses from semi-structured interviews

Theme	Coding category	Codes
Positioning	Headworn	Glasses, HMD, mirrors
	Handheld	Mobile, mirrors
Technology	Retinal	HTC Viva Pro, Android AR Core, IoS ARKit
	Optical	Holo Lens, Magic Leap, Android AR Core, IoS ARKit
Format	Outdoor	mobile
	Indoor	Mirror, telepresence
Design characteristics	Interactivity	Interaction, single or multi-user
	Quality of Augmentation	Brightness, Color, Contrast, Occlusion, Resolution, field of view, Stereoscopic, Dynamic refocus
	Type of use	Current, Emrging, not existing, experimental, proof of concept, Active Use
Barriers	Geographic	Specific regions of the world
	Social	
	Demographic	Yes, No
Technology limitations	Power	Battery life, need recharging
	Field of View	limited view

The responses from the qualitative surveys (Table 7) were used to map the needs of the retailer and customer to what the technology design characteristics provided. In this case, the data analysis presented a menu for what AR technology solution made sense in specific circumstances. These survey results were used in Part 2 of the case analysis when determining the deisgn for AR using the co-creation sessions in ICETS.

Table 7. Summary of the survey results for AR technology characteristics and where they apply

Positioning	Head-worn			Hand-held	
Technology	Retinal	Optical	Optical	All	All
Example	HTC Vive Pro	HoloLens	Magic Leap	Android ARCore	iOS ARKit
Mobile (Yes, No)	No	Yes	Yes	Yes	Yes
Outdoor Use (Yes, No)	No	Yes	Yes	Yes	Yes
Interaction (Yes, No)	Yes	Yes	Yes	Yes	Yes
Multi-user (Yes, No)	Yes	Yes	Yes	Yes	Yes
Brightness (Adjustable, Fixed)	Fixed	Adjustable	Adjustable	Adjustable	Adjustable
Contrast (Adjustable, Fixed)	Fixed	Fixed	Fixed	Fixed	Fixed
Resolution (Adjustable, Fixed)	Fixed	Fixed	Fixed	Fixed	Fixed
Field of view (Limited, Extensible, Fixed)	Fixed	Limited, Fixed	Limited	Limited	Limited
Full color (Available, Limited, Not Available)	Available	Available	Available	Available	Available
Stereoscopic (Yes, No)	Yes	Yes	Yes	Yes	Yes
Dynamic Refocus (Available, Not-Available)	Available	Not Available	Not Available	Available	Available
Occlusion (Yes, No)	No	Yes	Yes	Yes	Yes
Power Economy (Yes, No)	Yes	No	No	Yes	No
Opportunities (Current, Emerging, Not Existing)	Current	Current	Current	Current	Current
Extent of Use (Experiment, PoC, Active Use)	Active use	Active use	Active use	Active Use	Active Use
Barriers (Geographic, Social, Demographic, etc. - indicate all that apply)	regions of world (Geographic), Cost, VR enabled PC requirement	Cost, Avaiability in specific regions of world (Geographic)	None	Demographic	Demographic
Technology Drawbacks - indicate all that apply)	VR enabled PC requirement, Limited play area within base stations, wired HMD	limited FOV, short battery life, Slow charging, Uncomfotable to wear, cheap headstrap	FOV, short battery life, Uncomfotable to wear for a long period of time	Battery drain, FOV	Battery drain, FOV

The co-creation approach was used in Part 2 to understand user needs and why and how the AR solution should be designed (elaborated in Chapter 6). The co-creation sessions' observations were used in the data analysis to understand how human-centered characteristics could be applied to design AR to develop solutions to address the specified problem use case. Table 8 summarizes how the co-creation sessions' observations were codified and documented to apply to the analysis of the case. The human-centered characteristics theme was based on the findings from Chapter 5. The observation of the co-creation sessions with ICETS was transcribed to map the empirical evidence from the case study to the human-centered design characteristics.

Table 8. Coding of the themes and values from the co-creation observations

Themes	Values
Human Centered characteristics	User needs, user must-have, nice-to-have requirements, purpose, benefits, interface, interaction, feedback, testing, comfort, mapping to requirements, experience, monitoring
Technology	Ability to browse, get different details, search, compare, brand filtering, purchase, personalization, security, quality of 3D images, online, in-store, sample app, integration with data and security, social media feedback and comments
Retailer	What to stock on the shelves, inventory, labor cost, supplier relationships, competition, supplier network, online and in-store presence, shopping journey, customer feedback, customer experience improvements
Customer - Professional	Familiarity with innovation, engagement with new technologies, detailed content, fit for purpose, ability to search, evaluate and compare, ability to interact with sales associates, browse online, purchase in-store, choose delivery in-person or at home, provide feedback to others via social media integration, personalization, security, privacy, emotions, cognitive capabilities
Customer - novice	Novelty, easy to use and handle, ability to interact with sales associate, browse products, make purchases, interact with technology, choose delivery at home or in-store, emotions, cognition

These values were used in the case analysis to understand how the different types of users engaged in the sessions, their feedback and how that enabled the ICETS designers to develop the prototypes for the users to test and evaluate. The iterative development via multiple co-creation sessions was used to develop a feasible and viable solution to address the specific use case. The values for each of these themes were used to map the empirical evidence or observations to each of the constructs of the AR design model pertaining to the human-centered characteristics, the AR technology, the retailer's customer experience management and the consumer's perception of experience in the case.

Infosys Case

In the Infosys case, the responses from the semi-structured interviews, focus groups, observations, and observing a Design Thinking workshop (Appendix 10 and Appendix 11) were used for the data analysis to understand what design characteristics of the AR solution were needed to address the problem use case. The workshop ascertained user needs and expectations, a solution, and the solution's feasibility and viability for the retailer and customers. The Infosys Design Thinking approach used for the case is elaborated in Chapter 6.

Table 9 summarizes how the different data sources were used to gain value inputs as well as how that data gathering was conducted for further data analysis of the themes that emerged and the values from the empirical evidence from these data sources.

Table 9. Value inputs from the different sources - interviews, and observations

Source	Value inputs	How it was conducted
Semi-structured interviews	Understanding Design Thinking approach used by Infosys, steps taken and what was done in each step	Slide presentation
	Purpose of Design Thinking workshop - presenting the technology, samples, understanding feedback of what is going on, options for solution design	Design Thinking workshop
	When Design Thinking is used to design emerging technologies like AR, IoT, RFID, AI	Interview conversation
Focus Groups	Respondent-moderator format - one of the people participating was chosen as moderator	Had a questionnaire for the group
	Understand the problem statement	Inputs, opinions and explanations from participants
	Expectations from the solution and how that will be fulfilled	Exchanging ideas, points of view, including situation of solution in customer journey
Design Thinking	Hosting the workshop - workshop over 2-3 weeks	Identify participants with representation of retailer, Infosys, and customers, and Design Trainer
		Video of what the technology provides
		Identify problem, set up design challenges to get the participants familiar with DT
	Using Design Thinking workshop to solve problem use case	Clear understanding of the use case for retailer and customers
		Present current problems, issues and drawbacks
		Observe, document and sort the inputs into themes
		Participants inspect the themes at the workshop
		Inputs, updates and outputs are collected
		Brainstorm design opportunities
		Customer journey mapping using Post-It to address how the solution will fit
	Iterative design of feasible and viable solution	Infosys creates prototypes
		Infosys works with participants on feasibility of prototype by asking them to use it
		Validate the functionality and ensure it is viable and will prduce the desired outcomes
		Test the solution with other customers invited
		Solicit and document feedback
		Test next iteration until users are comfortable with feasibility and viability of solution

The documentation from the interviews, observations of the focus groups, and the design thinking workshop were themed and coded to apply to the case analysis. Table 10 illustrates summarizes how the documentation was codified. The values for each of these themes were used to map the empirical evidence or observations to each of the constructs of the AR design model pertaining to the human-centered characteristics, the AR technology, the retailer's customer experience management and the consumer's perception of experience in the case.

Table 10. Themes and values from Infosys data collection

Theme	Values
Human-centered characteristics	Problem to be solved, business model, user must-have, nice-to-have requirements, benefits, experience, mapping, iterating for feasibility, viability, testing, evaluation, monitoring
Technology	Interactive, ability to text out for physical clothing, store information for later purchase, security, privacy, personalized
Retailer	Product information, personalized, virtual try-out, reduce return, customer feedback, human interaction, up-sell options, make purchase decisions
Customer	Interactivity, experience, information, connected shopping journey, compare, sizes, colors, brand, price, texting, secure, privacy, interaction with employee, choose lighting, fitting room ambience, choice of language, delayedpurchases

The data collected from the two cases conducted provided context to identify steps for designing AR experiences with users. These steps were derived from the observations documented in both the cases for what the problem was, what was the retailer trying to solve in their digital journey, what were the expectations, what was the must have and nice to have requirmenst and how that mapped to providing the required experience, how to test and validate the iterations to determine a feasible and viable solution to address the specific use cases. These evidence descriptions from the cases were mapped to the steps for effective AR design to be used to develop a framework as described in Chapter 6. Table 11 illustrates the the steps for how to design AR experiences with users.

Table 11. Steps to design AR experiences with users

AR Design Step	Evidence description from data collected
Identify the need for the technology	Type of customer - professional versus novice, familiarity with new and emerging technology, does the technology solve a practicular problem or use case
Select a potential business model	Does the user expectations solve a particular retailer challenge in its digital transformation?, Does the technology target the specific users in the different retail formats?
Identify user requirements	level of involvement determines ideas for requirements, detailed versus nice to have, preferences, functionality expectations, differences between types of users,
Consider the must-have characteristics of the solution	degree of effort, no bottlenecks for interaction, level of information needed, will non-existence of the feature cause dysfunction or dissatisfaction?
Select a feasible subset of features	What features are needed for both the retailer and the customer to interact with the solution at a minimum with ease and no bottlenecks
Develop a technical solution	Can ordinary users use the solution? Target users that will have an enhanced experience, technhology and technical limitations known upfront
Evaluate and test the solution	Users knwo what is feaible and viable, can provide feedback for subsequent iterations,

2.7 Evaluating the Contribution

This research aims to address the research questions identified in Chapter 1 by developing a theoretical contribution that explains the impact of AR characteristics to enrich the retail customer experience. It also targets the design of AR to enhance specific retail experiences by developing an approach that builds on human-centered design and the upfront inclusion of users in the design process. The first contribution should be evaluated as a form of theory for describing and explaining. The second contribution should be evaluated according to theory criteria for design and action (Gregor, 2006).

2.7.1 Evaluation of the explanatory contribution

The explanatory model of AR's impact on customer experience, which is presented at the end of Chapter 4, is derived from applying the theoretical framework to analyze how AR can impact the retail customer experience. It covers the controllable elements of AR characteristics – information level, interactivity, and quality of augmentation – and presents how these characteristics create impact mechanisms on the retailer's customer experience management and how consumers perceive customer experience. These impact mechanisms clarify how the AR characteristics impact the retailer and the customer's constructs.

The explanatory model of AR's impact on customer experience will, as explained above, be evaluated based on how it contributes to explaining the relationship between AR and customer experiences in retail, as it was this need that initiated the model construction. As a type of explanatory theorization, it has two reasons for its existence: a) as a foundation for creating guidance for the design of AR solutions in retail (chapters 5 and 6), and b) a value per se, by answering the first research question posed in this thesis, which is valuable in its own right.

Generally, explanatory theories "need to be new and interesting, or to explain something that was poorly or imperfectly understood beforehand. With case studies, more than just a 'story' is expected, as to qualify as theorizing the exercise must lead to conclusions with some generality" (Gregor, 2006, p. 625). This can be summarized in the two conditions of *novelty* and *generalizability*. Novelty simply means that what is explained was not explained before. Generalizability in this study is, as has been described in chapter 4, a matter of creating generic logic that is valid within a defined context. Gregor (2006) also argues that generalizations should be assessed by plausibility, credibility, and consistency. For quantitative research, clearly defined numeric criteria determine what is acceptable. For qualitative research, Guba and Lincoln (1994, p.114) acknowledge, "The issue of quality criteria…is…not well resolved, and further critique is needed." However, some consensus also exists on qualitative research criteria, although the assessment is more subjective to the evaluator. Guba and Lincoln (1994) suggest four criteria widely used in qualitative IS research:

- Credibility – Confidence in the 'truth' of their findings. The degree to which results make sense. Credibility is built up through prolonged engagement in the field and persistent observation and triangulation of data.
- Transferability – Researchers are encouraged to provide a detailed portrait of the setting in which the research is conducted. The aim is to give readers enough information to judge the applicability of the findings to other settings.
- Dependability – The existence of a trail which can be laid open to external scrutiny (the documentation of data, methods, and decisions about the research).
- Confirmability – Auditing as a means to demonstrate quality. For example, the researcher can offer a self-critically reflexive analysis of the methodology used in the research. Also, techniques such as triangulation (of data, researcher, context) can be useful confirmability tools.

Combining the advice by Gregor (2006) and Guba and Lincoln (1994), the five evaluation criteria against which the explanatory model of AR impact on the retail customer experience should be assessed are: Novelty, Credibility, Transferability, Dependability, and Confirmability.

2.7.2 Evaluation of AR design guidance

AR design guidance is expressed as a human-centered approach specifically targeted to design AR to enhance the retail customer experience. This approach builds on the explanatory model seeking to articulate how to achieve AR's potentially positive impact. The explanatory model forms the kernel theory that provides the justificatory knowledge for the approach developed (Gregor and Hevner, 2013).

While the approach in the development did not follow a typical design research method (e.g., Carlsson et al., 2011; Sein et al., 2011), the ambition was to extract design guidance from the study of skilled practitioners in the field through a case study (c.f. Markus et al., 2002). The articulated guidance still forms a theoretical contribution in the sphere of what Gregor (2006) calls Theory for Design and Action. More specifically, the contribution falls into Level 2 of the Design Science Research Contribution Types:" Nascent design theory—knowledge as operational principles/architecture". While the contribution cannot claim to form a fully developed design theory, it should be evaluated as a step towards building such an approach.

This type of theory says" how to do something"." It is about the principles of form and function, methods, and justificatory theoretical knowledge that are used in the development of IS … " (Gregor, 2006, p. 628). Generally, a contribution in this area should help an important constituent solve a problem better than it could (c.f. Carlsson et al., 2011). Here, the target audience for the approach is designers and developers (from technology providers or actors within the retail industry) who are interested in the shaping of customer experiences.

Having this constituent in mind, the evaluation criteria for this contribution were derived from Gregor (2006) and set to be:

- Completeness – To what extent does the approach provide a sufficient solution to the design problem
- Simplicity/Ease of use – Are developers with adequate professional background and education able to execute on the approach
- Consistency – Are the components of the approach in harmony and effective towards the same objective
- Quality of results – Does using the approach lead to the outcomes sought

Following Gregor and Hevner (2013, p. 351), "It is important to note that some degree of flexibility may be allowed in judging the degree of evaluation that is needed when new DSR contributions are made. Particularly with very novel artifacts, a 'proof-of-concept' may be sufficient." The general human-centered approach was tested naturalistically (Pries-Heje et al. 2008) by two AR developers targeting retail (ICETS and Infosys). The researcher inferred learnings from the real-world use of the approach and articulated them as a set of principles for effectively using human-centered design in this specific context. This can be viewed as an initial step of approach evaluation that should, in subsequent research, be followed by other forms of assessment that also include the other principles developed in this thesis, in an iterative process of theory development and refinement (c.f. Carlsson et al., 2011).

2.8 Summary

This chapter presented the research methodology of the studies underpinning this thesis. Given the questions RQ1 and RQ2 (Chapter 1), the research is based on qualitative data with a preserved contextual link to identify findings, motivations for the results, the consequences of the findings, and their contributions. The use of a theoretical framework as a basis for the studies was essential to know which data to look for when interacting with the empirical phenomenon and ensure that the investigation extended the accumulated knowledge of AR and retail experience and human-centered approaches. A flexible design approach was required, involving mutual interaction of empirical findings and theoretical input, in iterative cycles. This was needed since AR in retail is still immature in terms of underlying technology, understanding, and use to date by its users. Much of the field is still at a stage of conceptualization and theorizing.

This chapter presented the criteria for selecting cases to address research gaps, the type of gathered data, how the collected data were analyzed to determine AR characteristics, and how they addressed and enhanced retail experiences (including a human-centered approach). The chapters that follow will detail the cases and their findings and contributions to IS and from a practitioner standpoint.

3 Related Research and Theoretical Framework

This chapter establishes the research foundation by reviewing relevant literature on AR and the retail context to form an initial theoretical framework. It begins with an overview of the AR phenomenon, including how it is distinguished from related phenomena such as VR. The chapter then highlights what retail is, how this domain is transforming, and the role of digital technologies in this transformation. The extant research studies on AR's impact in the retail context uncover areas that emerged as the research gaps to form the research scope. The chapter provides a theoretical basis for retail customer experience in different retail settings, resulting in a theoretical framework that will be used to understand how AR can enrich the retail customer experience. This chapter concludes with the current state of knowledge and the research gaps that were uncovered.

3.1 Augmented Reality

AR is one of several emerging digital interactive technologies such as Virtual Reality (VR) and Mixed Reality (MR) that combine physical objects and virtual objects via interactions in real-time by displaying elements in three dimensions (3D) (Azuma, 1997; Azuma et al., 2001). It is a view of the real-world environment with overlaid computer-generated images that change perceptions of reality (Milgram and Kishino, 1994a; Milgram et al., 1994b). The term was coined back in 1990 and found its first commercial uses within moviemaking, television, and military context. The emergence of the internet and smartphones enabled AR to experience a second spring, with broad application in various contexts, including retail (Peddie, 2017).

3.1.1 Definitions and characteristics of AR

One of the earliest formal definitions of AR was proposed by Azuma (1997). It identified three characterizing elements of AR technologies: the combination of real and virtual elements, real-time interaction, and the reproduction of content/elements in 3D. Building on Azuma's definition of AR and its three elements, several other authors have provided their definitions of AR (Table 12). These definitions emphasize the technical and user experience aspects of AR, and they convey that the natural environment is the main feature of AR, combined with sensory digital/virtual contents.

Table 12. Definitions of AR and prevalent elements (Caboni and Hagberg, 2019)

Authors	Definition of AR	Prevalent elements
Carmignani and Furht (2011)	AR is defined as a real-time direct or indirect view of a physical environment that has been augmented by adding virtual computer-generated information	Real time Physical environment Virtual information
Sood (2012)	AR converges the physical world with virtual objects, augmenting the view of the physical world with streams of information from the Web	Physical world Virtual objects
Ukwuani and Bashir (2017)	AR is aimed at improving and enhancing the way we perceive our surroundings by combining technologies such as computing, sensing and display technologies	Enhanced surroundings Combined technology
Olsson et al. (2013)	AR is a technique that combines real and computer-generated digital information into the user's view of the physical real world in such a way that they appear as one environment	Combination of real and digital information Physical world Real world
Scholz and Smith (2016)	AR seems to be an ideal technology for forging deeper relationships, as it fuses and	Ideal technology Forging relationships
Javornik (2016a, b)	AR is an interactive technology that modifies physical surroundings with superimposed virtual elements. The user can add textual information, images, videos or other virtual items to the person's viewing of the physical environment	Interactive technology Physical surroundings Virtual elements
Grewal et al. (2017)	AR is one of the emerging applications that will define the future of retailing	Emerging application Future of retailing
Hwangbo et al. (2017)	AR refers to the computer graphic technology that visualizes things that exist in the natural environment by combining computer-generated sensory inputs such as sound, video, graphics, or GPS data from the physical, real world environment	Computer graphic technology Natural environment Sensory input
Pantano et al. (2017)	AR is a real-time view of the physical world augmented with virtual computer-generated information	Real time view of the physical world Virtual information
Poushneh and Vasquez-Parraga (2017)	AR is a series of technologies that integrate real world and virtual information, enhancing a specific reality	Real world Virtual information
Rese et al. (2017)	AR integrates computer-generated objects with the real environment and allows real-time interactions	Real environment Real time interactions
Yim et al. (2017)	AR is defined as the superposition of virtual objects on the real environment of the user	Virtual objects Real environment
Brengman et al. (2018)	AR allows for the digital overlay of content to the user's real environment	Digital content Real environment
Lee and Leonas (2018)	It brings virtual and artificial objects into a real environment	Virtual and artificial objects Real environment
Poushneh (2018)	AR is an interactive technology that generates three-dimensional virtual content and then maps it onto the user's reality	Interactive technology Virtual content
Watson et al. (2018)	AR layers virtual elements over physical environments, and blends virtual worlds with reality. AR is a system to have these properties: combines real and virtual objects in a real environment; runs interactively and in real time; registers (aligns) real and virtual objects with each other	Virtual elements Physical environment Interactivity Real time

The most applied and accepted definition of AR (Azuma et al., 2001) is that AR is the conjunction of real and virtual imagery with real-time interaction and 3D registration. This definition states that technology adds to the real-world image with layers of digital information (Cipresso et al., 2018). The overlaid sensory information may be constructive (i.e., additive to the natural environment), or it might be destructive (i.e., masking of the natural environment) such that it is perceived as an immersive aspect of the real environment via visual, olfactory, or tactile means. The logic of interaction between humans and the system is designed based on the three interaction modes of sight, gesture, and voice.

AR comes in different display types and can work in various settings (Appendix 4 details the technology components of AR and types of AR). It comprises three foundational design components: (a) a tracking method that connects virtual and real worlds, (b) a projection device that transforms data to visual stimuli, and (c) a data feed that provisions data to process and display.

Technically, tracking registration technology is generally considered the critical design component of AR and is the main limitation to applying current AR solutions (Harrington et al., 2019). The registration task is to determine the mapping relationship of virtual objects in different coordinate spaces and display them in the image's correct position, in real-time, to achieve AR. The performance of registration positioning directly determines the success of the AR solution. Three-dimensional tracking registration can be divided into three categories: sensor-based tracking registration technology, vision-based tracking registration technology, and hybrid tracking registration technology (Machado and Vilela, 2020).

The ***tracking method*** deploys virtual images over real-world objects via one of these approaches:

- **SLAM:** Simultaneous Localization and Mapping (SLAM) localizes sensors to their surroundings, while at the same time mapping the structure of the environment.
- **Marker:** The marker-based method (also known as the Recognition method) uses a camera to identify visual markers or objects. Marker-based AR technology depends upon a device camera to distinguish a marker from other real-world objects.
- **Location**: The location-based method (also known as the markerless method) uses GPS, digital compass, velocity meter, or accelerometer to provide location data. The location detection features in smartphones enable leveraging this type of AR, making it quite popular.

The ***projection*** of data to visual stimuli typically uses one of these presentation devices:

- **Smartphones:** On **smartphone devices and tablets,** AR can be rendered either through location services, camera, or a combination of both (Butchart, 2011). The viewer can see the modified input from the camera on their screen.
- **Large displays: PCs and connected TVs** support relaying virtual objects over a webcam (Azuma, 1997). Since it is a hectic process to manipulate a tracker in front of a screen, there are not many AR applications on PCs or smart TVs.
- **Smart glasses: Head-mounted displays, glasses, and lenses** make AR an integral part of the entire field-of-view. It gives a more life-like AR experience, offering a broader scope of applications (Rauschnabel and Ro, 2016).

The ***data provision*** in AR brings data to overlay visuals in a three-dimensional space. Two primary forms include static and dynamic data provisioning.

- **Static data provisioning:** Augmented Reality technology brings life into static content. By looking through a handheld or head-mounted device, users can view virtual content superimposed onto static scenes and interact with the virtual content using various channels such as gesture or/and voice.

- **Dynamic data provisioning:** Dynamic data provisioning refers to the pace at which both structured and unstructured data is refreshed and the format in which it is available. These must support the need to make decisions while providing a customer experience that can understand the user's information.

Three characteristics that define AR technology are**:**

- **Vividness** or **quality of augmentation -** task completion and user feelings strengthened by the realism and quality of the medium's images.
- **Interactivity -** users expect to be able to interact with a device easily, **and**
- **Informativeness -** reducing uncertainty in the decision-making process where customers want and expect to find useful information in an easy and fast manner to support their actions and decisions.

Several authors have pointed their attention towards these characteristics (Huang and Liao, 2015; Pantano, Rese, et al., 2017; Rese et al., 2017; Rese et al., 2014; Yim et al., 2017). They can be considered essential measurement tools to explore AR's possible impact on customers and their interactions with this technology (Pantano, Rese, et al., 2017).

Augmented Reality versus Virtual Reality

The use of AR is based on the reproduction of 3D images of virtual objects. It is similar to VR, but it is essential to underline their main differences. AR is principally characterized by the superposition of virtual elements generated by a computer on users' real and physical environment (Cho and Schwarz, 2010; Drascic and Milgram, 1996). Even if AR's purposes and VR are similar, they address these aims in different ways. AR consists of reproducing virtual objects in the real environment, while in VR, the reproduction of the object is developed by devices that users have to wear (Milgram et al., 1994). More specifically, VR is defined as a realistic 3D environment produced by a computer (Burdea and Coiffet, 2003) and composed only of virtual elements (Milgram et al., 1994). VR obscures the actual reality, whereas AR enhances the actual view (Peddie, 2017). In AR, the user is still aware of the surroundings because they can still see the real world (Hsieh and Lee, 2015).

There is some overlap between hardware devices for AR and VR. A smartphone device can be used in either an AR or VR implementation, depending on the smartphone application. An AR experience will use the phone's camera, while a VR experience limits the user's vision to only the phone display. While VR is generally characterized by three degrees of freedom (3DOF), AR provides additional visual information augmented on the physical world with six-degrees of freedom (6DOF). 6DOF entails that the camera is positioned and oriented in three-dimensional space (i.e., forward/backward, up/down and left/right) in combination with changes in orientation (i.e., pitch, yaw, and roll) (ibid.).

Considering the differences between AR and VR, AR's positive effects are more appropriate for consumers. Through AR, for example, consumers have the opportunity to test several products/clothes without physically trying them (Verhagen et al., 2014; Yim et al., 2017). Porter and Heppelmann (2017) and Javornik (2016) suggest that only a limited number of retailers will adopt VR because its implementation is costly and time-consuming compared to AR. Besides, consumers seem to be reluctant to immerse themselves fully in a virtual world and prefer a setting in the real world with which they are familiar and comfortable (Bonetti, Warnaby and Quinn, 2018).

3.1.2 Extant research on IVEs in IS

A literature review was conducted using the research design and coding (Chapter 2) to understand the role of immersive technologies, namely VR and AR, in different domains. AR and the related concepts of VR that, together, form a technological cluster of Immersive Virtual Environments (IVEs) (Hofma et al., 2018), are subjects of growing interdisciplinary academic research. This literature investigated (a) the components that enable IVEs from a technological engineering standpoint, (b) users' readiness to adopt IVE-related technologies, and (c) the transformative impact of AR in a few specific contexts, predominantly gaming, healthcare, and education (ibid). The reference to the full paper that was published is in the footnotes of this page[13].

Brief History of IVEs

IVEs are digital spaces: "...in which a user's movements are tracked and his or her surroundings rendered, or digitally composed and displayed to the senses, in accordance with those movements" (Fox, Arena and Bailenson, 2009, p. 95). According to Fox et al. (2009) the goal of IVEs is: "...to replace the cues of the real world environment with digital ones" (Fox, Arena and Bailenson, 2009, p. 95). The more successful an IVE is in replacing cues from the real world with digital ones, the chance of immersing the user will increase. Immersion refers to a technology's capability to present a vivid IVE to its users while shutting out the physical reality. This is an important capability, as immersion can increase the likelihood

[13] Appendix1**Paper 1:** C. C. Hofma, S. Henningsson, and N. Vaidyanathan, "Immersive Virtual Environments in Information Systems Research: A Review of Objects and Approaches," in Academy of Management Proceedings, 2018, vol. 2018, no. 1, p. 13932: Academy of Management Briarcliff Manor, NY 10510

of a user feeling as if he or she is physically present in an IVE which in turn can increase, among other things, the effectiveness of mediated collaboration, communication (Colbert, Yee and George, 2016).

Researchers and scientists have tried to make IVEs more immersive by developing immersive hardware and software. For example, in 1965 a head-mounted display was developed by David Sutherland, an early pioneer within the field of virtual reality. However, it was so large and heavy it had to be mounted to the ceiling and it's: "...users expressed fears of bodily harm if the ceiling mount happened to break while they wore it." (Cummings and Bailenson, 2016, p. 273). During the 1990s, entrepreneurs and scientists had yet another go. While the technology had become more immersive through 3D graphics and higher resolution displays, head-mounted displays were still heavy and strenuous for the users. In addition, the hardware required to run the 3D IVEs could easily cost $30,000 placing it out of range for the average consumer. As a result, more IVEs remained a hype and was primarily confined to researchers. However, since the start of the 1990s the technological development has resulted in more powerful computers, smaller sensors and displays resulting in the affordability to buy and use cheaper head-mounted displays for virtual, augmented and mixed reality.

The objectives of this study was to understand the extant literature on the technology, context and the actors involved in the development and use and adption of these immersive technologies.

Technology: Hardware and Software Immersion

Building on the Slater and Wilburs (1997) factors of immersion, hardware and software immersion refers to the extent to which any given hardware and software can match a user's perceptions while delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a user.

Despite the importance of both hardware and software immersion, an analysis and subsequent coding of the 120 articles, reveals that 97 articles only account for or analyze the effect or role that the software has on users feeling of immersion. For example, by emphasizing the role that three dimensional space plays for immersion and presence of users (e.g. Goel et al., 2011; Saunders et al., 2011) or the influence or effect that embodiment through the use of avatars plays for immersing users in a virtual environment (e.g. Davis et al., 2009; Schultze, 2011; Ulrike Schultze, 2014). 14 articles mention or accounts for the immersive hardware setup, i.e. as a part of the experimental setup, but do not analyse it further (e.g. O Riordan, Adam and O'Reilly, 2009; Suh, Kim and Suh, 2011).

However, only 9 articles directly recognize or analyse the influence or effect that both the software and hardware can have on immersing its users. For example, by using two projectors and a pair of 3D glasses, Boese, M. et al. immersed geology students in a 3D IVE (Boese, Sheng and Salam, 2009). In another example, in a literature review on presence and embodiment, Schultze (2010) recognizes and mentions the potential role displays can have on users feeling a sense of presence in an IVE (Ulrike Schultze, 2010). Schultze and Orlikowski (2010) point out the importance investigating hardware immersion, by stressing the importance of using a performative lens in the research of virtual worlds. No articles only focus on the role or effect that hardware has on immersion of users.

Context

Eleven different contexts for the study of IVEs were identified. The most frequent context was education. 38 of the articles were related to an educational context. For instance, Schmeil (2012) developed a framework that elicited guidelines on how to design a Virtual World in an educational context. Virtual worlds were the second most investigated context with 33 articles. That is, these articles are situated in an IVE, typically Second Life. 14 of the 120 articles do not specify a context while 10 articles are situated in an unspecified business context. Retail and Marketing is fairly well represented with 11 articles, and is therefore the highest represented industry compared to the other represented industries: Health Care (2), Architect, Construction, and engineering (AEC) (1), Software industry (1), Human Resources (1), and product development (1).

Actors

The actor refers to the primary object that was observed. Some articles may have observed more than one type of actor, however in this review only the primary actors were included. The largest propor- tion of the articles, 17 %, observe users of the IVEs that use the IVEs for business. For instance, Schultze, U. (2014) investigated virtual entrepreneurs in Second Life with the aim how embodied identity is performed in virtual worlds (U. Schultze, 2014). Interestingly, only 10 % of the articles have looked at recreational users of IVEs i.e. gamers (Greenhill and Fletcher, 2013). 15 % of the articles did not specify or only in very general terms defined the actors observed i.e. students or subjects in laboratory experiments.

The third most observed actor is educators and learners representing 14 % of the articles. For example, in the article, Engaging group E-Learning in Virtual Worlds, Franceschi, K. et al. (2009), argues that Virtual Worlds are better suited for e-learning contexts than i.e. video conferencing equipment. They got the data by observing the students in an experimental setup.

The fourth and fifth most observed actors are that of experienced users and consumers both representing 11 %. Experienced users count those users, that have tried IVEs one or more times before they were observed. However, only 2 % of the articles investigated novice users of IVEs. Consumers were investigated in order to shed light on existing theories of consumer behavior, i.e. economic theories or to understand buying behavior of virtual goods or actual goods in an IVE (e.g. Animesh et al., 2011; Yang et al., 2012).

7% of the articles exclusively looked at academic articles (i.e. literature reviews). Yet another 7% of the articles examined documents and artefacts. The last and least represented actors are that of: Virtual designers (2%), Other users (1%), and Academics (1%).

After reviewing the references on IVEs from a technology context and actors' standpoint, it was evident that IS researchers have prioritized certain aspects over others. The typical IVE paper has studied IVEs based on software immersion in education or virtual worlds and strongly focuses on the user side. Another dominating trend is that the selected level of analysis is heavily skewed towards the individual. This choice goes hand in hand with an overwhelming focus on adoption, use, and continued use, as indicated by the frequent use of the Technology Acceptance Model (Davis, 1989), which is empirically quantitatively measured through survey data.

In short, after reviewing 120 articles on IVEs within the IS discipline, it can be concluded that there are significant gaps. In particular, IS research seemed out of touch with the technological developments of more immersive hardware, such as head-mounted displays and their use in real-life settings. Therefore, there is a call for a second wave of research, which will bring the maturing technology's broader social implications to the forefront. The goal of the second wave of IVE research should be to examine and identify the broad societal impact of IVEs, current readiness to cope with their transformative potential, and future possibilities to enhance the positive implications. At the same time, it is necessary to consider how to mitigate the negative effects that IVEs may have on individuals, organizations, and society at large.

3.2 Retail and Digital Technology

The increased deployment of technologies such as smart mobile devices and social networks and the growing importance of in-store technological solutions create new opportunities and challenges for retailers. The sections below discuss the concepts of retailing and how these technologies have impacted retail transformation.

3.2.1 Retailing as a context

Retailing has been expressed in different ways based on the premise on which it has been analyzed. Levy and Weitz (2011) define it as a set of business activities that add value to products and services being sold to consumers for personal or family use. It often occurs in retail stores or service establishments but can also occur through direct selling, using vending machines, door-to-door sales, or electronic channels (Pride et al., 2018). Berry et al. (2002) state that retailing is about creating a total customer experience by enabling customers to solve significant problems, capitalize on the power of respectfulness, connect with customers' emotions, emphasize fair pricing, and save time and energy. Kim (2001) defines retailing from multiple perspectives, including experiential consumption, symbolic consumption, entertainment retailing, themed retailing, and cross-shopping. These expressions and definitions emphasize the relationship between the customer and the retailer and how they experience this relationship.

For a customer, a retail store experience includes activities such as browsing, searching for merchandise, comparing prices, evaluating product variety and quality, and interaction with store personnel (Terblanche and Boshoff, 2001). The experiential value in retailing can be expressed through customer return on investment, service excellence, aesthetics, and playfulness dimensions (Mathwick et al., 2001). Burns and Neisner (2006) found that cognitive evaluation and emotional reaction can explain satisfaction experienced in a retail setting. The retailer's ability to create unique and pleasurable events keeps the customers delighted during the retail experience process and gives the retail store a distinctive image for identification and recognition. New format retail stores design their retail spaces better to understand their customers (Bagdare, 2016). In an era of new-age retailing, retail experience is emerging as the relevant means to attract, delight, and retain customers. It is primarily determined by the use of cognitive and emotional clues used in the retail environment, moderated by the customer and contextual characteristics, resulting in a pleasurable experience that leads to desirable retail performance (Bagdare, 2016).

3.2.2 Digital technology impacts to Retail

Technology is considered an enabler of competitive business advantage to satisfy consumers' demand for innovative and quality products and services (Chen and Tsou, 2012; Pantano and Viassone, 2014). The research on advanced technologies and the subsequent development of new systems to support retailers and consumers (Gunday et al., 2008; Pantano and Viassone, 2014) show that retailers are frequently subject to disruptive innovation processes that lead to the need to modify their traditional organizational process. Furthermore, the novelty produced by these new systems affects the familiarity and expertise of both the consumer and the retailer, with consequences for subsequent practical usage (Pantano and Viassone, 2014). These technological opportunities follow from the relatively recent emergence of advances in the internet, computing and storage capabilities, big data, IoT, and retail analytics. These trends have prompted the immense growth of internet-based retailing and enormous challenges and opportunities for the retail sector (Bradlow et al., 2017), giving rise to different retail formats beyond brick-and-mortar stores.

Digital technologies create multiple opportunities for retailers and customers regarding how the customer wants to interact with what the retailer has to offer. While online retail sales still represent a minority of the total sales across all channels, their growth rates are considerably outperforming brick-and-mortar stores (US Census Bureau, 2016). However, despite the many merits of electronic and mobile commerce, it is unlikely that traditional retail settings will cease to exist. Instead, these channels will complement each other in satisfying shopper needs (Zhang et al., 2010) through an integrated shopping experience (Verhoef et al., 2015; Piotrowicz and Cuthbertson, 2014).

Business models for retailers have been affected (Sorescu et al., 2011) with a changing retail mix, and customers are behaving differently due to these developments. To counter these developments, retailers have initiated multichannel strategies. These strategies revolve around whether new channels should be additive to traditional brick-and-mortar players' existing channel mix (Geyskens, Gielens, and Dekimpe, 2002; Deleersnyder et al., 2002). They also apply to new online players, who face whether they should be present offline (Avery et al., 2012). The scope of multichannel retailing considers customer management across channels and integrates the retail mix across channels (Neslin et al., 2006).

Brynjolfsson, Hu, and Rahman (2013) state: ¨In the past, brick-and-mortar retail stores were unique in allowing consumers to touch and feel the merchandise to provide instant gratification. Internet retailers tried to woo shoppers with wide product selection, low prices, and content such as product reviews and ratings.¨ Channels are now being used interchangeably and seamlessly during the search and purchase process, and it is difficult or virtually impossible for retailers to control this usage. As retailing evolves toward this seamless omnichannel retailing experience, the distinctions between physical and online will start to blur, turning the world of retailing into a ¨showroom without walls".

The advent of new digital and mobile channels has resulted in another disruptive change in the retail environment (Rigby, 2011). The essential difference between multichannel and omnichannel is that the different channels become blurred in omnichannel as the natural borders begin to disappear. Research shopping has gained some attention in the multichannel phase (Verhoef, Neslin, and Vroomen, 2007), but showrooming is becoming an important issue in the omnichannel phase. Shoppers frequently search for information in the store and simultaneously search on their mobile devices to get more information about offers and find more attractive prices (Rapp et al., 2015). The opposite of showrooming also occurs, referred to as 'webrooming', where shoppers seek information online and buy offline. Retailers can provide these seamless experiences, for example, by having tablets in the store, where customers can seek information about different products and order them. Alternatively, through in-store Wi-Fi networks, retailers can communicate with their customers through their mobile devices and track their behavior. Whereas the multichannel world mainly considers the number of retail channels, the omnichannel environment emphasizes the interplay between channels and brands. Neslin et al. (2014) describe multiple purchase routes to show how this interplay works. As such, the omnichannel world is broadening the scope of channels and integrating consideration of customer-brand-retail channel interactions. Omnichannel management is the simultaneous management of all accessible channels, and the customer touchpoints to optimize the cross-channel customer experience and the performance over channels (Verhoef et al., 2015).

From an operational standpoint, these retailing technologies are widespread (Newell, 2013; Efendioglu, 2015). Finne and Sivonen (2008) confirm in their studies that cost efficiency is a priority for implementing these digital technologies for retailers. Brick-and-mortar retailers face an erosion of their sales productivity as they struggle to redefine their role in an omnichannel world. To avoid consumers shifting their purchases even more online, they need to find a way to create a differentiating value proposition (Rapp et al., 2015; Pantano and Viassone, 2015). Shankar et al. (2011) and Newell (2013) suggest "technology utilization" as a promising weapon in the face of stiff competition from online players that will allow offline retailers to ride the wave of the digital revolution currently affecting the retailing landscape. It is now up to the physical retailer to follow-up on this evolution by assuming its reinvented role in the smart cityscape, reaping the rewards of the convergence between the physical and virtual shopping environments (Kent et al., 2015).

The current advances in technologies can enhance retailers' performance by optimizing their shopping experience (Pantano, 2014; Pantano and Di Pietro, 2012; Zhu et al., 2013). Advanced technologies like immersive technologies, biometric technology, IoT, and 3D scanning entail strategic potential as they frequently provide retailers with real-time feedback about customers (Renko and Druzijanic, 2014; Pantano and Naccarato, 2010). Furthermore, technological developments are a powerful driver of retail business model innovation (Sood and Tellis, 2010; Sorescu et al., 2011), and it is precisely this type of innovation that tends to result in substantial returns (Lindgardt et al., 2009).

3.3 AR in Retail

AR has emerged as a rapidly developing technology used in physical and online retail to enhance the retailing environment and shopping experience. However, academic research on and practical applications of AR in retail are still fragmented, and this state of affairs is arguably attributable to the interdisciplinary origins of the topic. The sections below cover AR's practical use in retail, followed by an extant literature review of AR in the retail domain to frame the basis for the research covered in this thesis.

3.3.1 The practical use of AR in retail

A significant theme in the existing literature relates to the way(s) in which users adopt, interact with, and experience technology devices and systems (Dix, 2009; Kjeldskov and Graham, 2003; Rogers, 2004). In particular, immersive technologies have attracted the attention of scholars and practitioners (Bonetti et al., 2017; Javornik, 2016; Pantano et al., 2017). AR is based on using a camera to capture real-world data and combine real and virtual sources into one perception (Ailawadi and Farris, 2017; Hwangbo et al., 2017; Oleksy and Wnuk, 2016). Consequently, product simulation, sound, GPS data, and media richness contribute to experiential value, with AR enabling consumers to interact with virtual products (McCormick et al., 2014). AR has the potential to modify the shopping experience (Watson et al., 2018). Increases in online shopping (Barlow et al., 2004), smartphone use, and the adoption of connected devices drive the growth of AR in retail markets and encourage retailers to adopt AR. Thus, retailers are increasingly embracing AR applications to create immersive customer experiences (Flavián et al., 2019; Watson et al., 2018). This reinforces the possibility of the retail store becoming an 'experience' where the customer can be delighted and even see the store as a destination creating a competitive advantage.

Practitioners have focused on several possible ways to enhance the retail shopping experience and how retail store environments can become more attractive (Pantano, 2010). It is essential to understand AR's role as an emerging point of sale option for physical stores, which will largely contribute to defining the future of retailing (Grewal et al., 2017). AR is being utilized to enhance customers' in-store experiences. Using AR, consumers can try on clothes and shop as if they were in a physical store. Importantly, consumers can also input their characteristics (e.g., face shape, hair color, skin color, and body figure) and immediately envision how they would appear in a given suit or dress, thus saving time and energy. This highly interactive experience transcends the conventional means of viewing a picture of the suit or dress and imagining how it would appear on oneself (Tang et al., 2004).

As AR continues to mature and consumers and retailers start to adopt it, it is interesting to see some tangible trends in how users look at AR in retail (Figure 2 and Appendix 3 for examples of AR uses in retail). Retailers can use AR to provide customers with virtual try-on opportunities to help them find the most suitable products for their needs (Brengman et al., 2018). AR has become an excellent opportunity for promoting retail stores and increasing customer attendance. Its advantages for retailers are increased speed for obtaining information about consumer behavior and, consequently, improvement in service at the point of sale, with positive influences on the consumer shopping experience (Flavián et al., 2019; Dacko, 2017; Pantano and Naccarato, 2010). Through AR, retailers can increase sales volumes by offering a personalized pre-purchase evaluation with mobile, web-based, and in-store applications (Dacko, 2017). As underlined by Scholz and Smith (2016), AR is essential for retailers to generate a memorable customer experience and create consumer engagement (Bonetti et al., 2018). AR may provide retailers with several opportunities to enhance the store experience for consumers and allow potential users to interact with products and touch them in an augmented way (Brengman et al., 2018). It is achieved by increasing consumer engagement (Javornik, 2016a, b), enhancing product tangibility (Vonkeman et al., 2017), and improving the willingness to buy.

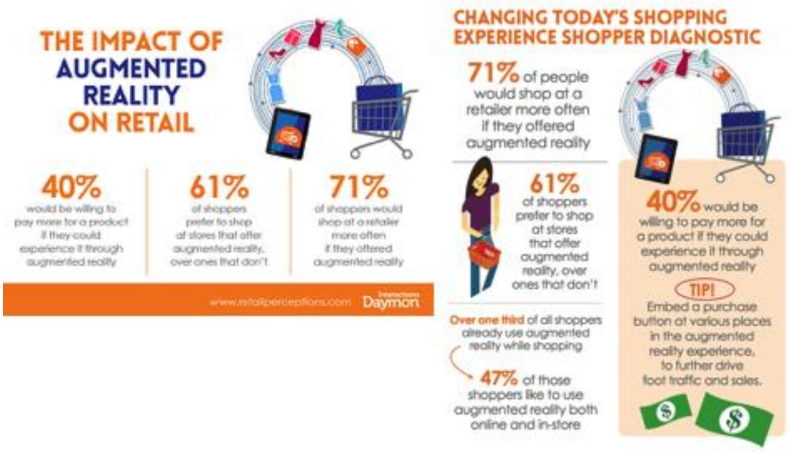

Figure 2. Impact of AR on retail customer experiences (Daymon, 2016)

3.3.2 Extant literature on AR in retail

A systematic review was conducted of AR in retail, for areas where it has been researched. The study included understanding the data analysis, the theoretical methods and models most commonly used, how data was collected, types of devices, and displays described in the different papers. The study also reviewed the extent of user interaction, how the senses were augmented, and learnings, limitations, and opportunities for ongoing research. The methodology used for this review is covered in Chapter 2.

There were few published papers (Figure 3) for AR in retail until 2011. The continued investments in technology and experimental studies by retailers to understand the technology's impact, particularly for clothing, show a spike starting in 2014. Many of the papers relate to how users experienced a particular study, POC, or experiment. Online and mobile trends are beginning to pick up. There is very little research on engaging users upfront or how this affected their experience. Most of the retail research is around the clothing area – try-ons, virtual fitting, smart mirrors, and virtual fitting rooms. The key reason for AR in retail has been related to shopping.

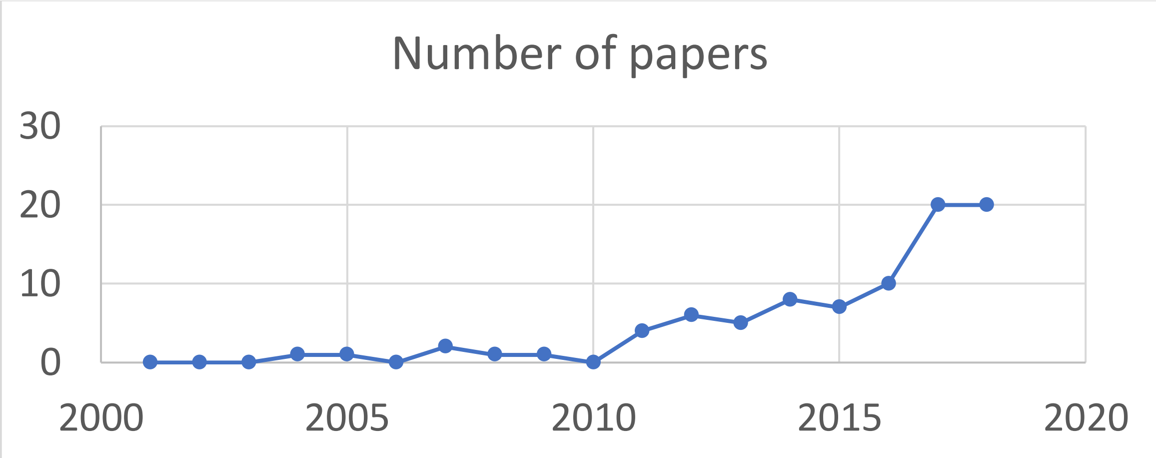

Figure 3. Number of papers relating to AR in retail

Most research methods (Figure 4) were based on experiments, building prototypes, or apps to understand the impact of the technology (Wiwatwattana, 2014) or understand how the users connected with the investigation or prototype. Empirical studies followed via interviews, existing literature, theories. The typical way to interpret outcomes was by surveys of participants supplemented by qualitative research; alternatively, there was just qualitative research using interviews, focus groups, and observations. Mixed methods were used sparsely.

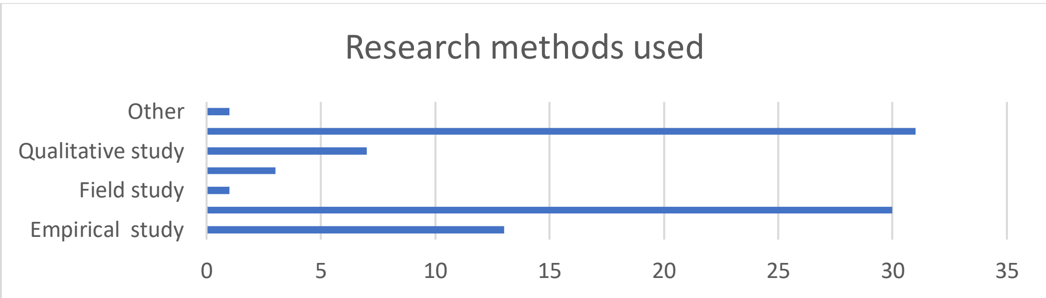

Figure 4. Research methods used in the papers

The key areas where the research was conducted (Figure 5) were in the clothing area. Papers show that this is primarily because users are keen to virtually fit on clothing using virtual fitting rooms and mobile applications. Groceries/food was the second area via kiosks and virtual vending machines. Several papers reviewed AR in retail from an empirical standpoint, related to product reviews, advertising, marketing, PoS, and servicing but without a focus on retail areas.

Figure 5. Focus areas for AR in retail research

The reviews showed that the critical AR devices in retail (Figure 6) were mobile, projection displays, mirrors, and, to a small extent, glasses, headwear, and lenses. There was no specific research that showed why specific AR devices are selected and what they could provide in retail. It was also unclear what devices created real-life needs versus long term use potential.

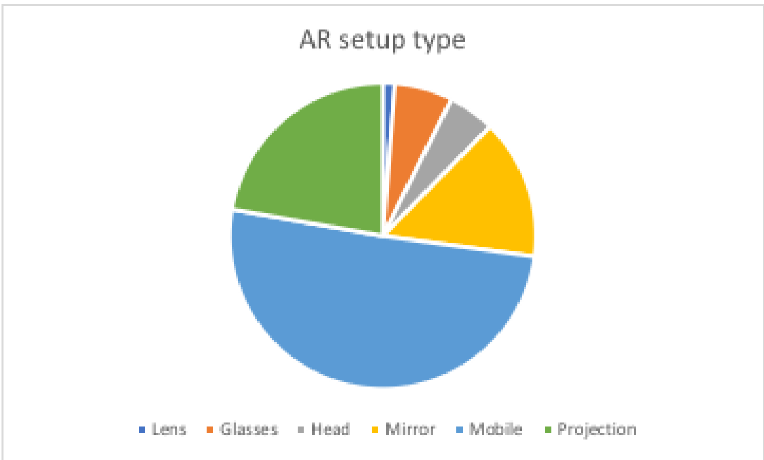

Figure 6. AR displays used in retail

Most papers reviewed had a prototype or application that was built to test a particular focus area like virtual fitting room, try-ons, kiosks, self-service vending machines, mirrors, and projection displays, and then surveyed participants for how they experienced the technology. Other papers included empirical studies that referenced the impact of AR in retail as an emerging technology in the engagement of retailers and customers, advertising, marketing, branding, and buying/purchase decisions.

Early research into AR, with interactive displays used in a physical retail environment, predicted users interacting with a steerable technology and triggering information on the product, promotions, and locations (Sukaviriya et al., 2003), thereby highlighting both its functional and hedonic aspects.

Subsequently, AR applications have become more popular due to widely distributed personal mobile technology, such as smartphones and tablets, allowing users to shop using AR apps (Rauschnabel, 2018), thereby enhancing satisfaction and experience (Dacko, 2016; Javornik, 2016). Early AR retail applications included virtual try-on using personalized or non-personalized virtual models, to show how apparel products (and combinations) would look, and interactive displays providing information on the promotion, products, and locations (Bonetti et al., 2017; Hwangbo et al., 2017). Subsequently, AR technology has evolved, and substantial growth of mobile AR took place, via the widespread adoption of smartphones and tablets (Javornik, 2016; Rauschnabel, 2018). Mobile AR apps constitute a form of consumer-led interaction, personalization,n, and customization. For example, IKEA's AR app can measure a real-life room through the camera's objective and render an authentic piece of furniture (Tabusca, 2014).

AR can improve consumers' visualization of products, increase engagement, and enhance perceptions of the shopping experience, thereby positively affecting retailer and brand perception. That, in turn, can influence consumer behavior (Huang and Liao, 2015; Hwangbo et al., 2017; Kannan and Li, 2017; McCormick et al., 2014; Poncin et al., 2017; Willems et al., 2017). Furthermore, consumers' perceived control and autonomy enhance retail experience in technology-mediated retailing (Poncin et al., 2017). Letting consumers maintain a degree of control while maintaining a degree of challenge, designed to increase user competence perception, leads to consumers' perceived enjoyment and increased shopping effectiveness, control, and convenience (Roy et al., 2017). Overall, this positively impacts the customers' perception of the retailer and their behavioral intentions (Roy et al., 2017). At the same time, however, information accessibility and consumers' perceptions of the degree of control over the collection and use of personal information by companies may lead to privacy concerns (Inman and Nikolova, 2017; Kannan and Li, 2017).

Other essential aspects relating to AR adoption in retailing include retailers' drivers and motivations for adopting the technology and the barriers they perceive. The former might include enhancing the customer experience, both in physical and online stores, by offering additional product information, or allowing faster product try-ons and simulations of product combinations, thereby improving operational efficiency and focusing on the practical benefits of the technologies (Bonetti et al., 2018; Hwangbo et al., 2017; Inman and Nikolova, 2017; Javornik, 2016). Other motives include facilitating online-offline shopping and accurate product inventory management for operational cost management and cost savings (Kannan and Li, 2017; Willems et al., 2017). AR adoption might also provide benefits relating to brand image and identity, associated, for instance, with being perceived as an innovative player by consumers and competitors (Bonetti et al., 2017). Key contributions identified from extant research in retail mapped to AR characteristics are illustrated in Table 13 below.

Table 13. Concept matrix for AR in retail themes and mapping to AR characteristics and integration

Author	Augmented Reality Theme	Augmented Reality Characteristics
Cuomo et al., 2015 Ross and Harrison, 2016 Javornik, 2016 Huang and Liao, 2015	AR can add levels of information to consumer knowledge and behavior, reshaping and integrating the commercial area itself. It allows for the generation of bottom-up and top-down content changes through social networking, and shifts the individual from tryer to buyer to advertiser. This enables generating greater value experiences and, therefore, additional sales	Different levels of information
Poushneh and Parraga, 2017 Pejsa et al., 2017 Kim and Hyun, 2016 Mantovani and Riva, 1999 Rese et al., 2017 Javornik, 2016 Hilken et al., 2017 Scholz and Duffy, 2018 Fuccio et al., 2016 Chen at al., 2016	The main AR attributes that produce satisfaction are rich quality of augmentation (realistic view and telepresence), elevated level of informativeness and interactivity, the availability of crucial utilities (search features, narration, quick response, and need for touch), connectivity (social features), and entertaining attributes. The more consumers interact with these AR attributes, the more satisfied they are; conversely, the less consumers are able to interact with these features, the more dissatisfied they are	Quality of Augmentation Interactivity, Connectivity and Entertaining attributes
Huang and Tseng, 2015 Huang and Liao, 2015 Javornik, 2016	Important implications for researchers and managers are drawn from the discrepancy and its consequences for consumer satisfaction. Augmented reality adds different degrees of information to the consumers' sense	Different Levels of information
Ajanki et al., 2011 Oh and Woo, 2009	AR reshapes the commercial area, providing it for contextual information and usable by potential customers when needed	Different levels of information
Bauer et al., 2001 Pysssysalo et al., 2000	Integration with the mobility reconfigures the mode of use, organizing new opportunities of connections with the user	Interactivity
Dacko, 2017 Hilken et al., 2018 Choi and Kim, 2004	By combining augmented reality store displays and price tags with customer loyalty programs, retailers have the ability to improve the customer's shopping experience	Different levels of information
Lu et al., 1999 Syberfeldt et al., 2017	Ease navigation inside the stores as well as make products more affordable	Different levels of information Quality of Augmentation
Bonetti et al., 2018 Poushneh, 2018	With more information available and with the enhanced experience available, retail stores are better able to compete with the rise in online retail shopping	Different levels of information Quality of Augmentation
Olson, 2012 Hilken et al., 2017 Zelthamy and Berry, 1993	While it will be years before AR becomes primary driver for many segments in the retail market, eventually it will turn into an interface that customers will grow to expect. Outcome of this research involves application of this technology in a retail space	Interactivity
Bulearca and Tamarjan, 2010	A rising number of marketers are considering using augmented reality for marketing purposes	Interactivity
Rauschnabel et al., 2019	Mobile augmented reality does influence consumer behavior and responses	Interactivity
Pantano et al., 2017	AR and consumer decision making	Interactivity

Challenges for acceptance and adoption

AR has evolved from a cumbersome head-mounted device to mobile phones, smart glasses, and lenses. Along its development path, AR has met some challenges since the technology is dependent on the advancement of computers and the digital network. AR still has many technical challenges regarding, for example, binocular (stereo) view, high resolution, color depth, luminance, contrast, the field of view, and focus depth. However, before AR becomes accepted as part of a user's everyday life, like mobile phones and personal digital assistants (PDAs), issues regarding intuitive interfaces, costs, weight, power usage, ergonomics, and appearance must also be addressed (van Krevelen and Poelman, 2010).

The extant research determined technology limitations, user acceptance, and adoption challenges to scale AR in retail.

Technology limitations

The extant literature has provided conclusions for why AR use has been limited in retail from a technology design attributes statndpoint. These attributes are being addressed as this technology continues to develop with the hardware and software maturing.

- **Tracking technique:** The biggest problem in real-time 3D tracking lies in the scene's complexity due to changing conditions and the targeted objects' motion. Moving objects may separate or merge due to occlusion or image noise, and target objects may also vary in appearance due to varying light conditions (Zhou, Duh, and Billinghurst, 2008). Objects in the distance cannot be reliably reconstructed and are, therefore, not used when the camera input is processed. Thus, the system cannot find identifiable markers like corners and edges on the targeted object, which means that the system cannot recognize the object (Zhou, Duh, and Billinghurst, 2008).
- **Augmented Reality displays:** There are several problems related to displays of AR devices that should be considered. For example, HMDs are flexible and portable, but if the user must wear them over an extended period, they might get uncomfortable, both to the head and the eyes. They have a limited field-of-vision and thus cannot effectively support collaborative work (Zhou, Duh, and Billinghurst, 2008). Spatial AR displays can support multiple users, are much easier on the user's eye, and reduce motion sickness and distraction, but have one big disadvantage: they are generally not mobile. Handheld devices are usually mobile but have other problems like tracking, small display, and unreliable sensors.
- **Connectivity:** Many of today's AR systems rely on the internet to provide data to display the augmented scene. For example, most AR applications on today's smartphones depend on the data downloaded from the internet, based on the user's position retrieved from the GPS. It might present a problem if the user is in an area that lacks internet coverage, especially if the AR application needs to retrieve large amounts of data from the internet (Jo and Kim, 2016).
- **Ability to update distance information and field of view**: Major limitations of the current AR devices are that they update distance information at only up to 1 Hz, impacting the visual perception of fast-moving objects. The display can provide low-latency self-motion information as it builds up a stable 3D map while the user moves around a stationary environment. System delays are a large source of dynamic registration errors (Azuma et al., 2001). System latency can be moderated through careful system design, and pre-rendered images may be shifted at the last instant to compensate for pan-tilt motions. Similarly, image warping may correct delays in 6DOF motion (both translation and

rotation). Critical information for several activities, such as navigation, often may fall in the peripheral visual field, so improvements in the display size are highly desirable. Optical and see-through video displays are usually unsuited for outdoor use due to low brightness, contrast, resolution, and field of view (van Krevelen and Poelman, 2010).

- **Hardware**: AR will likely have an essential role in the retail environment. It will require increasingly powerful microcomputers to drive AR. This capability is currently limited but will improve with time (van Krevelen and Poelman, 2010). Many limitations of the technology at present are related to the hardware, where battery life is limited, devices are large, and cables can be cumbersome. Most mobile AR systems are cumbersome, requiring a heavy backpack to carry the PC, sensors, display, batteries, etc. Connections between all the devices must withstand outdoor use, including weather and shock, but universal serial bus (USB) connectors are known to fail easily (van Krevelen and Poelman, 2010).
- **Depth perception**: Accurate depth perception is a difficult registration problem. Stereoscopic displays help, but additional problems, including accommodation-vergence conflicts or low resolution and dim displays, cause the object to appear further away than it should be (Drascic and Milgram, 1996). Correct occlusion ameliorates some depth problems as does consistent registration for different eyepoint locations (Wagner and Schmalstieg, 2003).

Usage limitations

The retailers and firms engaged with AR have been limited in different ways as described in the extant literature. These include the current state of maturity of the technology preventing its use mainstream and in everyday retailing.

- **Marketing and advertising:** A challenge of AR is marketing and advertising. Marketers hope to use augmented reality to place products or ads as part of the search features used on the applications. Given the current state, this is still an obstacle for retailers and customers (Rauschnabel et al., 2019).
- **Privacy:** An area of concern as augmented reality develops is privacy. This concern is increasing since the latest AR technology revolves around image-recognition software. The facial or image search could match profiles on many social networks and use personal data to provide birth date, marital status, or sexual preference (Rosener et al., 2014).
- **Distraction and over-reliance:** The system's interface must be adapted to be useful and straightforward to avoid overloading the user with information (van Krevelen and Poelman, 2010). The interface should provide the required information while allowing the user to be aware of his surroundings. Designing an interface that does not distract with unnecessary information will help prevent the user from missing important cues from his environment.

- **Social and usage acceptance:** Like any other new technology, getting people to use AR may present a more significant challenge than expected. When new technologies are introduced, the users are affected by both practical and social levels. The process of change requires knowledge about the new system and its domain. Nilsson and Johansson (2007) argue that an introduced system or interface should have as many positive effects on the user and his work as possible, while also reducing adverse effects. Further, they state that essential usability awareness implies that the interface or system should not be harmful or confusing to the user, but rather assist the user in the tasks.

Despite these limitations, AR has demonstrated value in experiential retailing of products such as apparel, cosmetics, and furniture, via an inexpensive approach toward product trials, thereby increasing the certainty of purchase decisions and reducing return rates. AR's capability to personalize the customer experience by enhancing physical reality enables a holistic shopping experience using sensory and omnichannel marketing strategies (Poushneh and Vasquez-Parraga, 2017). Retailers should collect customer feedback about AR experiences and adopt an open innovation approach while designing marketing strategies (Rauschnabel et al., 2015).

While designing AR, retailers should be aware that as the user's exposure to AR increases, the novelty factor associated with AR decreases (Hopp and Gangadharbatla, 2016). As customizing AR requires collecting and storing personal data, retailers need to disclose the collected personal data and detail of its potential usage to increase adoption and address privacy concerns. Designing AR-based strategies requires retailers to consider the impact of cultural differences on experience. Existing studies also demonstrated that online reviews form an excellent source of information to identify AR applications (Rese et al., 2014).

Before integrating AR into their offerings to address customer experience, retailers should assess AR for various dimensions. These are compatibility with the product category (Cho and Schwarz, 2010), customer's personality traits (Huang and Liao, 2014), user's perception about body image (Yim and Park, 2019), technology readiness of the ecosystem, and organizational traits (Chandra and Kumar, 2018). Retailers should be cautious while choosing between different types of AR (Brito et al., 2018) and provide users with an opportunity to experience and enhance digital content (Cho and Schwarz, 2012) to provide avenues for experience co-creation among customers and retailers (Huang, 2019).

The next section extends the extant research of AR in retail to understand what retail customer experience is and how AR characteristics can play a pivotal role in enriching retail customer experience.

3.4 AR and the Retail Customer Experience Perspective

The retail industry is subject to a dramatic shift in the logic of competition; from a traditional transaction focus on "buy low, sell high and optimize everything in between" to the creation of complete customer experiences (Jain et al., 2017; Sorescu et al., 2011). In the retail industry, the transformative effects of ARs will offer retailers the opportunity to transform how people shop (Cullen, 2016), challenging retailers to develop radically different capabilities to seize opportunities (Philips, 2017). The next several sections examine retail customer experience, the theoretical frameworks, and models used in the extant literature, how AR has been used in retail customer experience, and build a theoretical framework that serves as the basis for the case analysis in Chapter 4.

3.4.1 The retail customer experience

Customer experience literature originated from aspects of consumption and services marketing (Holbrook and Hirschman, 1982), that later expanded to branding (Brakus, Schmitt and Zarantonello, 2009), then to consumer behavior research (Gentile, Spiller, and Noci, 2007) and retail environments (Grewal, Levy and Kumar, 2009). Though a relatively new concept in both theory and practice, customer experience has gained attention in the last few decades, evolving into a strategic process for creating holistic customer value and for achieving differentiation and sustainable competitive advantage (Gentile, Spiller, and Noci, 2007; Verhoef et al., 2009).

A traditional product or service value proposition is no longer adequate for reaching customers or creating differentiation. Businesses must focus on the customer's experience, similar in importance to products and services, to create a seamless total experience (Carbone and Haeckel, 1994). Organizations redefine their offerings in terms of "personalized co-created experiences" (Prahalad and Ramaswamy, 2004b). This shift represents managing business with an experiential perspective. It warrants the need to develop new competencies to create and manage great customer experiences that provide pleasurable experiential memories.

Customer experience is a major focus of both contemporary research and management practice. A meaningful experience is important for achieving competitive advantage and satisfied customers for different organizations (Bolton et al., 2014; Verhoef et al., 2009). The "customer" in the customer experience has been interpreted as a "consumer", "user", "participant", "co-creator" (Bolton et al., 2014), "guest" or "actor" (Lusch, 2011). The experience is strongly linked with the value obtained as perceived by the individuals involved (Helkkula et al., 2012).

These experiences are uniquely and contextually interpreted, and they emerge whether an organization chooses to recognize and influence the experience or not (Vargo and Lusch, 2008). It is holistic and encompasses the customer's cognitive, emotional, affective, physical, and social responses to any contact with the service provider, product, or brand, across multiple touchpoints (Bolton et al. 2014; Meyer and Schwager, 2007). In other words, customer experience is created by elements that the service provider can control (e.g., service interface, atmosphere, assortment, price). It is also produced by the influence of other customers or devices like smartphones that customers choose to use in various situations.

The term customer experience has taken on different definitions and concepts. The retail customer experience, conceptualized as a psychological construct, is defined as the consumer's "internal and subjective response" to any direct/indirect contact with a retailer (Meyer and Schwager, 2007 p. 118). The customer experience can be defined as a sum of all experiences and perceptions a customer has while purchasing goods or services with a retailer, based on all interactions and thoughts about the retailer's underlying products and services. It is an individual experience, whether conscious or subconscious, during a transaction in a store (Gilboa et al., 2003). When a retailer successfully delivers and creates a differential experience to customers, the probability of spending in the store is high. Besides, experience also can inspire loyalty from customers (Richardson, 2010). Studies state that whatever the product or service a business organization offers to the customer to buy or receive, that customer will experience as good, bad, or indifferent (Johnston and Kong, 2011).

It is an issue that companies cannot fully control experiences because experiences inevitably involve perception, feeling, emotion, and unexpected behavior from customers. According to Yoo, C.J., Park J.H., and Maclnnis D.J. (1998), to deliver customer experience, the retailer must know the customer better than ever before. The more relevant the business's offer, the closer the relationship between the company and the customer (Yoo et al., 1998).

In a retail setting, direct contact typically entails physical interactions with retail stores, products, or services. Indirect contact may involve unplanned encounters with representations of the company, or products and services such as advertising or product reviews, which occur increasingly online (Novak, Hoffman, and Yung, 2000; Rose et al., 2012). Similar to image, customer experience contact results in a "take-away impression" formed by the consumer and stored in their long-term memory (Carbone and Haeckel, 1994). Thus, customer experience overlaps with the image concept through customer involvement with the retail environment.

Customer experience is also considered holistic, as it may begin with anticipation and the journey to the store through to the completion of the shopping trip (Gilmore and Pine, 2002; Haytko and Baker, 2004). Yet, the holistic aspect potentially delimits the customer experience, leading to conceptual and measurement issues. For example, which part of the experience is to be measured - perceptions of specific elements or the total experience? (Palmer, 2010).

Terblanche and Boshoff (2001) defined retail customer experience as all the elements that encourage or inhibit customers during their contact with a retailer. Customers engage in various activities while selecting a retail store, shopping, and during post-shopping stages, leading to a complete experience and determining their satisfaction levels and repeat visits. There are enough pieces of evidence to show that retail customer experience has a significant impact on retail sales, satisfaction, more frequent shopping visits, larger wallet shares, loyalty, profitability, word of mouth communication, and image formation (Donovan and Rossiter, 1982; Lucas, 1999, Wong and Sohal, 2006; Grewal et al., 2009; Verhoef et al., 2009).

(Carbone and Haeckel, 1994; Schmitt, 1999; Gentile et al., 2007; Verhoef et al., 2009) sum up retail customer experience as "the total of cognitive, emotional, sensorial and behavioral responses produced during the buying process, that involves a coordinated series of interactions with people, processes, objects, and environment in retailing."

Despite increasing attention from academic researchers and practitioners, the term customer experience in retail remains a nebulous and unclear concept, having been "widely used and abused" in its ambiguous application (Palmer, 2010). Definitions vary from a hedonistic to a utilitarian viewpoint. Moreover, from a retail environment perspective, there are two important gaps. To date, the customer experience literature refers to the consumer's interaction with one brand, retailer, or service. Furthermore, there is limited empirical evidence regarding the composition of customer experience or how it may be captured and measured in a retail setting and affected by active interaction with digital technologies. There is also no standard customer experience framework or model to describe this evolving definition and customer experience features.

3.4.2 Customer experience theoretical frameworks and models

Leading retailing and customer experience journals were reviewed (see Chapter 2) to understand the theoretical frameworks and models most commonly used to understand the retail customer experience. The set of most commonly used models and frameworks was examined (Havif, 2017) to establish how they were referenced or cross-referenced, or whether they were unique models that represented gradual development in this field, especially to identify the key dimensions through which they perceive customer experience. Some models reflected the rise of e-commerce, some built upon old approaches to deepen the understanding of customers' perceptions. The dimensions of some models are more concrete and focused on the customer as an emotional human being; some, on the other hand, focused on the process of acquiring goods or services.

- **SERVQUAL Model:** There are five dimensions of the SERVQUAL scale (Parasuraman et al., 1988) – reliability, responsiveness, assurance, empathy, and tangibility. Reliability represents the provider's ability to reliably and accurately deliver a service promised to the customer, including keeping promises related to the delivery, pricing, or complaint handling. Responsiveness is about providing prompt service and personnel's attitude towards customer complaints, requests, and questions. The overall ability to build trust and confidence between the company and the customer is assurance. Empathy evaluates the individual approach and the attention the company provides to each customer. Tangibility contains the appearance of all the elements that represent the service in its physical form (e. g., facilities, equipment, personnel).
- **Total Retail Experience Framework:** Berman and Evans (1998) define total retail customer experience as all the elements that encourage or inhibit consumers' contact with the retailer. Two groups of dimensions influence the experience. The first group consists of non-controllable dimensions. These include aspects such as adequacy of street parking, the timing of deliveries from suppliers, and taxes, not controllable by the retailer. The controllable dimensions consist of six dimensions that the retailer can indeed control: personal interactions that provide numerous opportunities for creating and fostering long-term bonds with customers; perceived product quality, which is the consumer's perceived value of a product and how that affects the evaluation of the retailer; product variety and assortment where customers expect to find a selection of different kinds of products consistent with their shopping intentions and preferences; store environment that contributes to the atmospherics of both offline and online environments across channels and omnichannel; product prices that influence decision making; and store policies that relate to the retailer's responsiveness to customer's needs.
- **eTailQ Experience Model:** The underlying motive for this model is that quality is related to customer satisfaction, retention and loyalty in both product and service settings and is therefore expected to be a determinant of online retailer success as well. Wolfinbarger and Gilly (2003) establish the four dimensions of the etail experience, and develop a reliable and valid scale for the measurement of etail quality. The four dimensions - website design, fulfillment/reliability, privacy/security and customer service - are strongly predictive of customer judgments of quality and satisfaction, customer loyalty and attitudes toward the website. Website design, which includes all the website elements that can influence the customer's experience, such as navigation style, information search, ordering process, or personalization. The fulfillment/reliability dimension evaluates the accuracy of the product's description on the website and the delivery of the right product at the promised time. Customer service, another dimension, which should be quick,

responsive, and helpful. The fourth dimension, security/privacy, is based on the security of payments and privacy of all shared information.

- **E-S-QUAL Model:** Developed by Parasuraman et al. (2005) supports the measurement of both pre- and post-e-service quality aspects and includes the following four dimensions: Efficiency - the ease and speed of accessing and using the site since convenience and saving of time are generally considered as the main reasons for shopping online. Fulfillment - the extent to which the site's promises about order delivery and item availability are fulfilled and are elements of service quality that lead to customer satisfaction or dissatisfaction. System availability - the correct technical functioning of the site. When consumers purchase from an online shop or they are just surfing, function problems like non-working buttons or missing links, disappoint customers and can lead to exiting. Privacy - the degree to which the site is safe and protects customer information. Many people are still not willing to purchase products from the internet because of the risk that is related to maltreat of personal information. Online retailers are becoming more acquainted of the importance of providing consumer privacy.
- **Consumption Experience Model:** Fornerino and de Gaudemaris (2006) identified five basic customer experience perception dimensions. The first dimension, called sensorial/perceptual, is the dimension that reflects the stimulation of senses. The affective dimension refers to the moments of strong emotions, excitement, joy, pleasure, or sadness. The physical/behavioral dimension describes the visible manifestations aroused by the most intense moments. Social is the next dimension related to the interaction, even the communion, with other people (friends but also unknown). The cognitive dimension contains thoughts produced during the event, whether related to it or not.
- **Customer Experience Model:** Gentile et al. (2007), drawing on past literature, created a model with six main dimensions of customer experience. Sensorial whose stimulation affects the senses such as sight, hearing, touch, taste and smell and could create aesthetical pleasure, excitement, satisfaction, and sense of beauty. Emotional which involves one's affective system through the generation of moods, feelings, emotions to generate emotional experience and could create an affective relation with the company, its brand or products. Cognitive related to thinking or conscious mental processes to engage customers in using their creativity or in situations of problem solving that a company could lead consumers to revise their usual idea of a product or some common mental assumptions. Pragmatic, the practical act of doing something refers to the use of the product in the post- purchase stage, but it extends to all the product life-cycle stages. Lifestyle coming from the affirmation of the system of values and the beliefs of the person through the adoption of a lifestyle and behaviors. Relational that involves the person and their social context, the relationship with other people or also with their own ideal self to leverage products which encourages the consumption together with other people or which is the core of a common passion that may eventually lead to the creation of a

community and finally the product can be also a means of affirmation of a social identity that induces a sense of belonging or of distinction from a social group where the link with the lifestyle dimension is very relevant.

- **Conceptual Model of Customer Experience:** Verhoef et al. (2009) developed a conceptual model of customer experience creation based on prior research. This model's first dimension is the social environment based on customer-to-customer interactions, such as customers' interactions with other customers in retail space and interactions with family or friends shopping with the customer. The second service interface is similar to the first one as it relates to the interactions between the customer and company employees (e. g., retail staff, service personnel). The retail atmosphere dimension includes aspects such as in-store music, the color of the interior, and placement of the equipment. Assortment represents the company's ability to provide a wide range of different, unique, and quality products. The price dimension consists of all the company's benefits, from loyalty programs, personalized promotions to customized products. Customer experience is nowadays perceived from the multichannel perspective, so one channel's experience can impact the experience in another channel. This fact is captured by the sixth dimension called customer experiences in alternative channels. The last dimension, retail brand, considers that customers buy products from one brand in a store that belongs to another brand in many cases. So, the resulting experience is determined by the expertise provided by both these brands.
- **EXQ Framework:** Klaus and Maklan (2012) conceptualized and validated the EXQ framework for measuring the customer experience. From a wide variety of sub-dimensions, they defined four main dimensions that influence the overall perceived experience. The first dimension, product experience, advocates that customers want to have an opportunity to choose from a range of products and to have the ability to compare different offerings. The outcome focus dimension is based on reducing the customer's transaction costs (e. g., searching for new providers). The moments of truth dimension reflects the quality and flexibility of the company's service if complications arise. The fourth dimension, peace of mind, represents all the customer's appraisals, mainly of an emotional nature, of his whole customer journey.
- **Theoretical Customer Experience Model:** This model (Stein and Ramaseshan, 2016) considers touchpoints (communications, technology, atmospheric, process, employee-customer interactions, customer-customer interactions, service or product interactions) moderated by motivation orientation (hedonic or utilitarian) affecting customer experience, and resulting in outcomes (loyalty, purchase). It is controlled by innovativeness, shopping enjoyment, and price consciousness.
- **Integrative Customer Experience Framework:** This framework (Kranzbühler et al. 2018) organizes the customer experiences literature according to the organizational and consumer level of analysis, and whether the works take a static (structural) or dynamic (process) view on customer

experience. It includes the dimensions of contextual conditions, employee-customer interactions, customer journeys, co-created experiences, consumer-consumer influences, personal characteristics, sequential effects, and negative impressions.

- **Integrated Customer Experience Framework:** This framework (Saini and Singh, 2019) considers service excellence, CROI, aesthetics, and playfulness to create a frictionless or pleasurable customer experience, resulting in a behavioral response.

Table 14 below summarizes the dimensions from the different frameworks and models described (Havif, 2017). The review of papers to understand retail customer experience shows that several models emerged in reaction to changes in the market environment. Most of the authors use the dimensions of customer experience devised for their specific research. There is an overlap in dimensions between the different frameworks and models studied, and there is no universal framework or model or variations of one.

Table 14. Overview of the dimensions of most used customer experience theoretical frameworks and models

SERVQUAL model (Parasuraman et al., 1988)	**eTailQ experience (Wolfinbarger & Gilly, 2003)**	**E-S-QUAL (Parasuraman et al., 2005)**	**Consumption experience model (Fornerino, 2006)**	**Customer experience model (Gentile et al., 2007)**	**Conceptual model of customer experience (Verhoef et al., 2009)**	**EXQ framework (Klaus & Maklan, 2012)**	**Total Retail Experience framework (Berman and Evans (1998)**	**Integrated customer experience framework (Singh, 2019)**	**Theoretical customer experience model (Stein and Ramaseshan, 2019)**	**Integrated Customer Experience framework (Kranzbühler et al. 2018)**
Reliability	Website design	Efficiency	Sensorial/ Perceptual	Sensorial	Social environment	Product experience	Personal interactions	Service excellence	Touchpoints	Contextual conditions
Responsiveness	Fulfillment/ Reliability	Fulfillment	Affective	Emotional	Service interface	Outcome focus	Perceived prdouct quality	Customer return on investment	Motivation orientation	Employee.customer interactions
Assurance	Security/ Privacy	System availability	Physical/ Behavioral	Cognitive	Retail atmosphere	Moments of truth	Product variety and asortment	Aesthetics	Outcomes	Customer journys
Empathy	Customer service	Privacy	Social	Pragmatic	Assortment	Peace of mind	Store environment	Playfulness	Innovativeness	Co-created experiences
Tangibility			Cognitive	Lifestyle	Price		Product prices	Frictionless or pleasurable experience	Shopping enjoyment	Consumer-consumer influences
				Relational	Customer experiences in alternative channels		Store policies	Behavioral response	Price consciousness	Perspnal characteristics
					Retail brand					Sequential effects
										Negative impressions

Next, an extant review was conducted on how AR related to retail customer experience, to determine the customer experience dimensions and theoretical framework, model, or variation to serve as the basis for my research analysis.

3.4.3 AR and the retail customer experience

Early research into AR, with interactive displays used in a physical retail environment, predicted users interacting with a steerable technology and triggering information on the product, promotions, and locations (Sukaviriya et al., 2003), thereby highlighting both its functional and hedonic aspects. AR applications have since become more popular due to widely distributed personal mobile technology, such as smartphones and tablets, allowing users to shop using AR apps (Rauschnabel, 2018), thereby enhancing satisfaction and experience (Dacko, 2016; Javornik, 2016).

Three crucial characteristics that define an AR technology are vividness or quality of augmentation, interactivity, and informativeness. Several authors have pointed their attention towards these attributes (Huang and Liao, 2015; Pantano, Rese, et al., 2017; Rese et al., 2014; Yim et al., 2017). These features can be considered important measurement tools to explore AR's possible impact on customers and their interactions with the technology (Pantano, Rese, et al., 2017).

Vividness is an essential characteristic of AR technology since both task completion and user feelings are strengthened by the realism and the quality of the medium (Lo and Lie, 2008). The degree of vividness is crucial to assess an experience (Lombard and Snyder-Duch, 2001). The possibility of interacting with AR that presents vivid and realistic 3-D animations of a specific product generates a feeling of being part of the experience (Faust et al., 2012; Ryan, 1994).

Interactivity refers to the user's expectation to interact easily with a device (Wang et al., 2015). AR-based systems on mediums such as smartphones and tablets, offer larger interactivity capabilities than desktop and in-store mediums. Interactivity directly impacts users' reactions and therefore influences their valuation regarding AR (Hoffman and Novak, 2009). It is considered interactive in that it lets users interact and modify the augmented setting (van Noort, Voorveld, and van Reijmersdal, 2012). Interactivity and vividness have been defined as antecedents of the effectiveness and the enjoyment of AR (Jiang and Benbasat, 2007; Yim et al., 2017).

The informativeness level has been identified as another significant predictor of users' attitudes towards a technology (Chen and Tan, 2004; Chen and Wells, 1999). In particular, Hausman and Siekpe (2009) consider it to be of great importance. Along with its implicit capacity to deliver experiential value to customers, AR can reduce their uncertainty in the decision-making process (Dacko, 2017). Customers want and expect to find useful information in an easy and fast manner to support their actions and decisions (Fassnacht and Koese, 2006).

Findings from the extant review

AR retail applications included virtual try-on using personalized or non-personalized virtual models showing how apparel products (and combinations) would look. Interactive displays provide information on promotions, products, and locations (Bonetti et al., 2017; Hwangbo et al., 2017). Subsequently, AR technology has evolved, and substantial growth of mobile AR took place via smartphones and tablets (Javornik, 2016; Rauschnabel, 2018).

AR can improve consumers' visualization of products, increase engagement, and enhance perceptions of the shopping experience, thereby positively affecting retailer and brand perception. This, in turn, can influence consumer behavior (Huang and Liao, 2015; Hwangbo et al., 2017; Kannan and Li, 2017; McCormick et al., 2014; Poncin et al., 2017; Willems et al., 2017). Consumers' perceived control and autonomy enhance the retail experience in technology-mediated retailing (Poncin et al., 2017). Letting consumers maintain a degree of control while maintaining a degree of challenge, designed to increase user perception of their competence, leads to consumers' perceived enjoyment and increased shopping effectiveness, control, and convenience (Roy et al., 2017). Overall, this impacts positively on customers' perceptions of the retailer and their behavioral intentions (Roy et al., 2017). At the same time, however, information accessibility and consumers' perception of company control over the collection and use of personal information may lead to privacy concerns (Inman and Nikolova, 2017; Kannan and Li, 2017).

Dacko (2017) identifies two different kinds of explicit benefits that AR offers to consumers: extrinsic benefits such as efficiency and greater value, and intrinsic benefits such as entertainment. This concept reinforces other academic research, suggesting that hedonic and utilitarian components affect consumer behavior throughout the experience (Hsiao et al., 2016; Lusch and Vargo, 2006; Wang, Malthouse, and Krishnamurthi, 2015). Similarly, service experiences are judged in terms of both hedonic and utilitarian value (Bauer, Falk, and Hammerschmidt, 2006), where the first refers to the experiential enjoyment (emotional value) and the second to the performance-related effectiveness of the service encounters (cognitive value) (Hilken et al., 2017).

According to Pine and Gilmore (1998), the customer experience develops around the two dimensions of customer participation and environmental relationship. Consumers perform key roles in co-creating the experience; the latter ranges from absorption to immersion, where the customers feel part of the experience (Pine and Gilmore, 1998). Users must be allowed to live their association with the brand in a delightful way to add value for the customers and create memorable experiences (Sorooshian, Salimi, Salehi, Nia, and Asfaranjan, 2013).

Online shopping increases and provides customers with the products and services traditionally present in offline experiences (Yim et al., 2017). It includes virtual try-ons, try-out tools, and training where customers get vivid contextual information. In offline settings, AR provides customized and interactive information previously absent in physical settings (Olsson et al., 2013). This is via the additional integrated value that AR enables, like personalization and authentication via analytics and big data (Bermejo et al., 2017). By providing varying levels of information on products and services, AR provides virtual tagging product ratings and details about products, providing customers immediate access to social communication. AR enhances the customer experience by merging the physical world's touch-and-feel with highly vivid, customized, and connected digital content. It naturally blends online and offline experiences to overcome the limitations of any individual distribution channel. For managers, AR addresses the concerns of showrooming and webrooming and maintains customers as they switch between channels during their journey (Olsson et al., 2013).

AR provides for novel in-store experiences and increased engagement by providing seamless access to digital content in offline settings, traditionally available only to online shoppers. Like the filter functionalities of online shops, recent AR applications also let customers visually highlight or de-saturate products in the physical assortment to personalize their choice set. AR offers firms a powerful tool to create memorable in-store experiences, increase the fun, and the time spent in-store. It delivers on digital customer experience imperatives for offline retail in several ways (Deloitte, 2016): by offering better price comparisons, by providing the ability to browse products and navigate assortment, including enhanced information about product features, variations, and availability. From an omnichannel perspective, augmenting the in-store experience promises to promote store loyalty while counteracting customers' loss to online shops, reduced in-store traffic, and showrooming behavior.

Integration of AR with other technologies like AI, Big Data, IoT, Payments can create value-added services for retailers and consumers to improve the retailing and shopping experience. It enables personalized product offers, preferred delivery methods, and improved decision-making (Bermejo et al., 2017).

Using integrating elements into the online environment, AR offers multiple opportunities to enable omnichannel customer experiences. It addresses concerns in the online environment related to product trials, leading to abandonment, product returns, and webrooming behavior. AR applications empower customers to try-on, selecting make-up or try-out products as if they were in an offline physical experience. It provides customers with authentic experiences in their shopping journey via an embedded offering, virtually present in an appropriate personalized environment (Huang and Liu, 2014). Hilken et al. (2017) studied the utilitarian and hedonic value of AR by proposing a fit with the situated cognition model that customers preferentially use in everyday shopping situations. AR's uniqueness in the online channel is that, by focusing on these conceptual dimensions, it affords customers the means to directly examine offerings in a personally relevant context.

Customer-to-customer connectivity is increasingly important to deliver omnichannel customer experiences (Verhoef et al., 2017), and the early absence of AR social features has been a limiting factor in the technology's proliferation (Javornik, 2016a). Recent applications have begun to address this limitation by enabling extended AR experiences. This highly visual, context-sensitive form of communication enables peer customers to become active contributors to shared customer experience (Scholz and Smith, 2016) rather than being limited to "liking" or commenting.

3.4.4 The theoretical framework used for the research

No studies have taken a holistic retail customer experience-perspective of AR, although some related research observations point to the relevance of this perspective. From the review of the most commonly used theoretical frameworks and models for customer experience (section 3.5.2), customer experience's key dimensions were ease of use, personal interactions, service provided, emotions, social context and influence, enjoyment, and decision-making environment. Other dimensions that were not universal related to the marketing mix, service mix, brand and loyalty, and product price.

The crucial AR characteristics are quality of augmentation or vividness, interactivity, and customer information levels. The ability to integrate with other digital technologies to provide value-added services enables a more significant AR (section 3.5.3) by adding levels of information to consumer knowledge and behavior and reshaping and integrating the commercial area itself. Through the generation of bottom-up and top-down content changes through social networking, the individual can shift from being an experience seeker to making purchasing decisions and advertising the AR technology, helping retailers provide more value experiences for their customers and increasing sales (Ross and Harrison, 2016; Javornik, 2016; Huang and Liao, 2015).

The integrative customer experience framework (Kranzbühler et al. 2018) was chosen to systematically investigate the impact of AR in the context of retail customer experience. It is based on the extant research for retailer customer experience management, retail customer experience, and the critical theoretical frameworks and models. It includes how AR relates to the customer experience from both the retailer and customer standpoint. This framework organizes the customer experiences literature according to both organizational and consumer levels of analysis, and according to whether the works take a static (structural) or dynamic (process) view on customer experience (Table 15).

Table 15. Customer experience framework

Focus area	Key construct	Indicative references
Organizational - static	Contextual conditions	(Mathwick et al. 2001; Surprenant and Solomon 1987)
	Employee-customer interactions	(Bitner 1992; Wilder et al. 2014)
Organizational - dynamic	Customer journeys	(Patrício et al. 2008; Wilder et al. 2014)
	Co-created experiences	(Akaka and Vargo 2015; Chandler and Lusch 2015)
Consumer - static	Consumer-consumer influence	(Chen et al. 2009; Kim and Lee 2012)
	Personal characteristics	(Holbrook and Hirschman 1982)
Consumer - dynamic	Sequential effects	(Ross and Simonson 1991; Verhoef et al. 2009)
	Negative impressions	(Sivakumar et al. 2014; Tax et al. 1998)

Customer experience is the aggregate and cumulative customer perception created during learning about, acquiring, using, maintaining, and disposing of a product or service (Carbone and Haeckel, 1994; Jain et al. 2017). An experience occurs when a company intentionally engages individual customers in a way that creates a memorable event. The "organization needs to create a cohesive, authentic and sensory-stimulating total customer experience, that resonates, pleases and differentiates an organization from the competition, to build an emotional connection with customers" (Berry and Carbone, 2007). The interaction between the organization making an offer and the intended consumer is the central tenant of customer experience (Jain et al., 2017). Experiences occur due to encountering, which provides emotional, cognitive, behavioral, and relational values (Schmitt, 1999).

Customer experience research on the organizational level of analysis seeks to explain how organizations create and manage customer experiences. Within this analytical level, the static view identifies the factors that contribute to an experience. These include environmental conditions, such as colors, sound, physical distance, inventory levels, and other store customers. The static view also deals with the design of the service. While some studies stress the importance of personalizing every touchpoint (Mathwick et al., 2001; Surprenant and Solomon, 1987), others identify employee-customer interactions to allow for personalization. Employees' ability to empathize and anticipate customer needs is key to service experience (Bitner, 1992; Wilder et al., 2014).

The dynamic view of the organization's creation of customer experiences is based on the production of customer journeys. It involves consideration across multiple channels within the same company, both offline and online (Patrício et al., 2008; Wilder et al., 2014). Blueprinting the customer journey has become a technique to visualize the steps involved in service, including execution times and costs. In blueprinting customer journeys, scholars propose designing a "dramatic" series of events with peak moments (Stuart and Tax 2004).

A stream of literature argues that customer experiences are produced within a broader network of actors that create value for the customer. This adds to the dynamic nature of the organizational creation of customer experiences. With the terms "value constellation" (Patrício et al., 2008) and "service ecosystem" (Chandler and Lusch, 2015), explanations have moved away from the notion of the purely one-on-one firm–customer relationships to focus on the coordination of touchpoints distributed among different actors.

Based on the consumer level of analysis, the static view has focused on the factors that determine how the consumer perceives and values the consumer's experience. These defining factors include other customers in the store. Other customers have an impact through mere presence. Some consumers experience high customer density discomfort, termed the 'sardine effect' (Chen et al., 2009). Present customers also affect experience by their age, gender, and appearance (Kim and Lee, 2012).

The second group of factors influencing the consumer's perception of the experience are the personal factors, including monetary and time resources, task definition, involvement, the nature of the search activity, and individual psychographics (Holbrook and Hirschman, 1982). The goal of a retail store visit (e.g., urgent purchase, large quantities, looking for a gift) significantly influences store choice and the salience of store attributes. Age and culture are also critical private factors (Poon et al., 2004).

The dynamic view of how consumers perceive customer experiences focuses on the sequential effects across a series of touchpoints between the customer and a firm. Research has located specific critical indicators in the perception formation, including the first touchpoint (Bolton and Drew, 1992), the peak experience performance (Kahneman et al., 1997), the negative peak performance (Verhoef et al., 2009), the average of performance (Koopmans, 1960) and the final touchpoint (Ross and Simonson, 1991).

A strand in the dynamic view has honed in on the negative impressions in customer experience. Because consumers regularly adjust their reference or expectation levels, they give a better assessment of dynamic customer experience when delight follows failure, rather than the other way round (Sivakumar et al., 2014). The firm's actions after a service failure is a defining moment of the customer experience. At times, successful service recovery had generated an even more positive experience than before the service failure occurred (Tax et al., 1998).

As a vehicle for the interaction between the retailer and the consumer, AR holds the capacity to influence the customer experience. AR embodies the organizational aspiration to create a positive experience that sets the firm apart from the competition. AR also forms one of the customer journey touchpoints that affect the consumer's perception of the experience.

Considering the key attributes and characteristics of AR (quality of augmentation, interactivity, information levels) discussed in this section, the resultant framework brings together these AR characteristics and the customer framework. This resulting framework serves as the basis for the AR impact case study analysis (Figure 7).

AR characteristics

- Different levels of information – bottom-up and top-down content
- Quality of augmentation – realistic overlays of 3D objects in physical world
- Interactivity - Utilities (search, narration, content, need for touch), connectivity (social features), entertaining attributes (look and feel)

Customer Experience Framework

Focus area	Key construct	Indicative references
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Consumer - static	Consumer-consumer influence	(Chen et al. 2009; Kim and Lee 2012)
	Personal characteristics	(Holbrook and Hirschman 1982)
Consumer - dynamic	Sequential effects	(Ross and Simonson 1991; Verhoef et al. 2009)
	Negative impressions	(Sivakumar et al. 2014; Tax et al. 1998)

Figure 7. Theoretical Framework for AR and Retail customer Experience

3.5 Summary of the state of knowledge and outstanding research issues

While this chapter contributes to an overview of a relatively recent but rapidly emerging theme that has so far not been sufficiently reviewed, it raises important issues for future research. First, based on the identified elements of AR, which consists of technology, context, and the user experience, it was found that given AR's origin and initial development, much progress has occurred in technological aspects among practitioners and in the research literature. Less is known about user experiences and the contexts in which AR is used and how these affect the retail customer experience. These are areas to further explore empirically for retailers and customers and business-oriented retail research. Specifically, research should address the implications of AR in terms of its effects on retailing, its integration within retailing, and the value it provides for customers (Hagberg et al., 2017). Second, research is needed to combine in-depth case studies of AR applications within retailing with cross-case analyses to compare different types of retailers and situations. The purpose would be to understand the conditions under which AR is more or less suited to the context of retailing and to what extent the potential values of AR are also realized in practice. Third and finally, it becomes important to research how the design of AR solutions is affected by engaging customers and retailers upfront to understand the specific needs that require an AR solution and how AR will enhance a particular retail customer experience gap or challenge. This aspect was missing in all of the literature reviews conducted. AR will call for and provide several opportunities for retailing research in the coming years. It will require different approaches and combinations of approaches to realize this technology's full potential in retail customer experience.

Extant research has not explored the effects of AR on the offline channel experience. The prevailing literature in offline environments focuses on technology acceptance, user evaluations, and affective customer reactions (Dieck et al., 2015; Olsson et al., 2013; Rese et al., 2014). Similarly, there is limited research on how online environments provide customers with the cognitive elements of having embodiment and extension while making decisions (Hilken et al., 2017). There is limited research to explain which attributes AR must provide to enhance customer's experiences (Poushneh and Vasquez-Parraga, 2017), the contexts in which customers are willing to use AR (Rauschnabel and Krey, 2017), and how AR can enable customer satisfaction and value (Ross and Labrecque, 2017).

Customer experience research thus far remains fragmented, with still relatively little known about the phenomenon. Most customer experience knowledge is derived from practitioner-oriented journals or management books (Holbrook, 2007; Verhoef et al., 2009; Rawson et al., 2013). Consequently, the focus has primarily been on managerial actions and outcomes rather than on theories underlying antecedents and consequences of customer experience.

Several practical implications can be drawn from this chapter. First, one main feature that distinguishes AR from VR is that it combines virtual and physical elements. Thus, AR is particularly suitable for the ongoing hybridization within retailing that is blurring the digital and physical domains rather than treating them as separate (Hagberg et al., 2016; Grewal et al., 2017); thus, it constitutes an opportunity for retailers in such an emerging landscape. Second, AR may provide opportunities for multiple applications that could be used and combined in different settings, including physical stores, consumers' homes, or other places where consumers are on the move. Third, the review outlined various values that may be adjusted to specific situations suitable for different retailers. Rather than a "one size fits all" solution, AR provides opportunities for a variety and diversity of applications of value, for many forms of differentiation, in an increasingly competitive retail landscape.

4 Using AR to enrich retail customer experience

This chapter reports on the analysis of two cases studied to establish the relationship between AR and retail customer experience. In one, a consortium led by Mastercard developed and tested an AR solution based on smart glasses and to be used within a physical retail store. In the other, Danish designer house Louis Poulsen commissioned the development of an AR app for smartphones that could be used to visualize its designer lamp in the home environment.

4.1 Case 1: In-store Retail: Integrated AR Smart Glasses – Saks [14]

Mastercard Labs, ODG, and Qualcomm initiated an AR project with the overarching purpose of understanding how integrating AR with other value-added services, including authentication and digital wallet, impacted the customer's use of AR. The solution was used to know what products were available, to make product choices, to try on variations of clothing, and ultimately to know whether a purchasing decision was made, and a means of delivery was addressed. It was conducted using a proof-of-concept in Saks Fifth Avenue retail store in New York.

The AR project included four collaborating organizations:

Mastercard: Mastercard is a technology company in the global payments industry. It operates the world's fastest payments processing network, connecting consumers, financial institutions, merchants, governments, and businesses in more than 210 countries and territories.

ODG (Osterhout Design Group): ODG, based in San Francisco, CA, is a leading wearable technology company that develops and manufactures mobile, self-contained and lightweight, head-worn, mixed reality smart glasses, with photorealistic imagery. ODG has worked with several partners to explore possibilities with smart glasses and immersive environments. It also provides a developer toolkit for integration.

[14] Appendix 1 **Paper 2:** Vaidyanathan, N. (2020). ICVARS 2020: Proceedings of the 2020 4th International Conference on Virtual and Augmented Reality SimulationsFebruary 2020 Pages 27–34https://doi.org/10.1145/3385378.3385383

Qualcomm: Qualcomm Incorporated, based in San Diego, CA, is a multinational semiconductor and telecommunications equipment company that designs and markets wireless telecommunications products and services. It derives most of its revenue from chipmaking and the bulk of its profit from patent licensing businesses.

Saks Fifth Avenue: It is an American chain of luxury department stores. Saks is owned by the oldest commercial corporation in North America, the Hudson's Bay Company. Its flagship store is located on Fifth Avenue in Midtown Manhattan, New York City.

For Mastercard, this was not the first AR project. The company engaged in multiple proofs of concept in immersive virtual environments – some directly with retail partners, others in partnership with other technology leaders - to understand how they could continually innovate and leverage their payment strength in the virtual set up. Smart mirrors, VR, smart glasses, AR, and mobile AR are some techniques used. The arrangement with Saks Fifth Avenue was to provide a technology solution integrating AR smart glasses with authentication and payments. The solution allowed for assessing how customers used and experienced the integrated smart glasses, whether the solution inhibited a purchase intention due to privacy concerns, and whether a purchase intent was made.

The AR solution was intended to let customers view digital representations of products before committing to a purchase. It would also enable them to be more educated about what they were buying, see additional options not available in the physical location, and get instant recommendations or other information relevant to their unique experience. When done shopping, users could pay for what they selected using Masterpass, which authenticated the user's iris, using Qualcomm Technologies' iris authentication. The customer could then select a card from their Masterpass-enabled digital wallet and complete the purchase by pressing the Masterpass button on the screen. Products could be taken home from the store or shipped, depending on availability.

In the press release related to the proof of concept, the three companies' leaders had this to say:

> "At Mastercard, we are seeing major shifts in how commerce is conducted, as people lead increasingly connected, digital lifestyles," said Executive Vice President, Digital Partnerships, Mastercard. "As the physical and digital worlds blend, we are focused on developing solutions that provide merchants with the ability to accept payments across all technology platforms possible—in-store, in-app, online, and in AR and VR—to help drive how people will experience shopping and payments in the future."

> "ODG is delighted to work with Mastercard and Qualcomm Technologies, fellow leaders in their respective fields, to offer a look into the future of shopping and purchasing habits," said Founder and CEO at ODG. "This solution showcases the transformative nature of augmented reality in the retail space and highlights the

> power and performance of ODG smartglasses and the unparalleled potential for head-worn AR to change the way we see and experience the world."
>
> "Qualcomm Technologies' iris authentication and extended reality technologies for Snapdragon 835 are designed to support a future generation of contextually aware commerce experiences using secure, augmented reality," said Director, Product Management, Qualcomm Technologies, Inc. "We are delighted to work with Mastercard and Saks Fifth Avenue to showcase new AR experiences on ODG's sleek, smart glasses based on our Snapdragon 835 Mobile Platform. Our commitment to innovation has the potential to deliver more personalized in-store experiences in the future."

Mastercard, ODG, and Qualcomm Technologies worked together to develop this prototype technology to help retailers find innovative ways to enhance the in-store shopping experience and to generate incremental sales by sharing relevant content and information with the shopper. With this solution, shoppers can visualize a full outfit, access additional clothing in the online inventory, and pay for it. It means retailers can stock fewer items in the store and move to a boutique showroom approach. It dovetails with the trend of shoppers buying whole outfits, rather than individual items. The consumer wears the smart glasses while shopping and the glasses display digital descriptions of a physical product that the consumer looks at — such as its price. Consumers can then purchase items using Masterpass and verify their identity through an iris scan.

The key concepts involved in the development were:

- Masterpass, the digital payment service from Mastercard, and Identity Check Mobile, which authenticates users making purchases with physical traits including fingerprint, facial and voice recognition software;
- ODG's expertise to lead the development of the AR shopping experience, as well as its award-winning extra-wide-field-of-view R-9 smart glasses with enhanced iris tracking cameras;
- Qualcomm's Snapdragon 835 Mobile Platform, which ran the Snapdragon XR SDK and iris authentication technology which includes liveliness detection for a superior authentication experience;
- Augmented Reality Payments SDK integrates Mastercard Digital Payment Services such as MPGS and Masterpass, support for mobile and headsets, and voice controls into an SDK to help merchants create an immersive commerce experience. It enables them to add payment checkout services for express and standard checkouts.

Figure 8 depicts the Integrated AR smart glasses and how they were used at Saks 5th Avenue.

The integrated technology was created to provide a digital experience for the customer's shopping journey. It was based on the different technologies used to develop the projection (ODG R9 smart glasses), data provisioning (computer imagery with high-speed processor and field vision), and rendering (deploying the computer imagery over the real world using markerless rendering). The glasses were lightweight, had higher battery life at lower costs, and a high field view vision. Though the primary objective was to test the acceptance of the integrated technology in-store, this case aimed to use the test scenarios to understand the perceived ease of use of the technology and how that affected the experience over time. The intention was to determine whether it was useful to make product decisions, whether the technology was more of a fashion accessory, given the trendy smart glasses, or for entertainment to use the voice commands and the field vision and computer imagery to enjoy the set-up.

Figure 8. Integrated AR smart glasses at Saks 5th Avenue

Mapping the case to the theoretical framework

AR characteristics and how they impacted the retail customer experience

This case provides a useful context for how AR's key characteristics of interactivity, quality of augmentation, and information level can enhance and enrich retail customer experience. This case also uses AR in an integrated environment where authentication and payment options are integrated with the smartglasses. It also shows how an in-store customer journey could create new touchpoints in the customer journey. The integrated smart glasses provided an excellent opportunity for both the retailer and the customer to engage in their customer journey differently; however, the integration was not seamless. The information level was not enough to understand the size, price, brand effectiveness clearly. The AR smart glasses still have to improve to provide the right interactivity, quality of augmentation, and information levels. The goal was to give the customer the possibility to experience the AR retail set up as an option for making a purchase in-store, virtually trying on the outfits, being authenticated, making a purchasing decision in-store, and then picking up the product or having it delivered home. However, this goal was not fully met because the set up was not frictionless and because this was a high-end store where users wanted to touch and feel the clothes. The technology is still not mature, and the integration between the smart glasses, authentication, and the digital wallet was not seamless for acceptance and active use from either a utilitarian or hedonic standpoint. The set-up did not create a frictionless experience for the users; however, it provided an avenue of possibility for future enhancements for better customer experience and decision-making and overcoming retail experience challenges._The maturing AR devices must meet these expectations and provide proof of whether AR revolutionizes in-store clothes shopping over time.

Table 16 below summarizes the impact of the AR characteristics and also highlights critical evidence from the interviewees.

Table 16. Summary of findings - AR characteristics and impact on retail customer experience with the integrated AR smart glasses

AR characteristics	Description	Indicative Empirical evidence
Information level	Bottom-up and top-down content	¨Exploring is just part of the fun. Next comes combining and dressing! Once the shopper has found their outfit, they can dress the life-size AR mannequin at the center of the space with their desired outfit. You can envision future releases enabling the ability to select from a vast array of different mannequins that can reflect more accurately body shape and dimensions of the individual shopper." (VP of Headworn, ODG)
Quality of Augmentation	Realistic overlays of 3D objects in the physical world	"We have heard from many marketing agencies and brands who are interested in developing unique, memorable consumer experiences at events, with our AR smart glasses as a first step in familiarizing themselves with the platform and its capabilities." (Founder, CEO, ODG) "We expect these activities to grow rapidly in the coming years. Retailers are starting to show interest in installing an experience like this Saks demonstration." (Founder, CEO, ODG)
Interactivity	Utilities (search, narration, content, need for touch), connectivity (social features), entertaining attributes (look and feel)	¨Aside from a couple of Bluetooth options and the ability to use your phone as a controller for both units, the only onboard controls were a small selection of buttons on the right side. I personally would find this at least a bit awkward, as one of the many left-handed people in the world. Maybe they will have a version with left-handed controls as demand increases for these products.¨ (Reviewer of ODG smartglasses) "customized and secure shopping experience" along with "relevant information while they are shopping." (EVP, Digital Payments and Labs, Mastercard) "Many high-end retailers like Bonobos, Paul Evans, Marc Jacobs, and Restoration Hardware are rethinking inventory strategies to reduce footprint and cut costs—moving to a 'boutique-showroom' approach, stocking fewer items in-store and offering a broader selection through online." (EVP, Digital Partnerships, Mastercard). "The AR smart glasses experience allows the shopper to organically merge the benefits of retail and online shopping together, giving them access to further inventory that may not be available in-store while maintaining that richer in-store experience." (EVP, Digital Partnerships, Mastercard)

Organizational level impact

The static and dynamic impact of the integrated AR smart glasses on the organization's creation of customer experiences (Kranzbühler et al., 2018) is summarized in Table 17. The relevant static influences that organizations can address include contextual conditions and employee-customer interactions. Regarding the contextual conditions (Mathwick et al., 2001; Surprenant and Solomon, 1987), Saks sought to enhance the physical retail experience by providing integrated AR smart glasses. It was to enable customers to enjoy the aspects of the glasses and use them to make decisions without having to wander around the store to try and pick out products in-store. Saks is a luxury retailer that thrives on employee-customer interaction. This proof of concept provided an option to see how the employees could focus on the relationships with customers rather than individual transactions.

Vice President of Headworn ODG states:

> "You can interact with the digital content while shopping; if you like an outfit, you can put it in the digital shopping cart." He added, "Within the next couple of years, glasses and other head-worn devices will become more revolutionary. Stores will have the potential to create a VIP experience for their best customers."

The integrated AR smart glasses can increase Saks's options for how to enrich the customer experience in-store. Executive Vice President of Digital Payments and Labs at Mastercard said that the technology would provide consumers a "customized and secure shopping experience" and "relevant information while they are shopping." Inventory management is one such parameter that is specifically targeted.

Executive Vice President, Digital Partnerships, Mastercard explained:

> "Many high-end retailers like Bonobos, Paul Evans, Marc Jacobs, and Restoration Hardware are rethinking inventory strategies to reduce footprint and cut costs—moving to a 'boutique-showroom' approach, stocking fewer items in-store and offering a broader selection through online." "The AR smart glasses experience allows the shopper to organically merge the benefits of retail and online shopping together, giving them access to further inventory that may not be available in-store while maintaining that richer in-store experience."

Introducing the smart glasses earlier in the customer decision-making process, where the products are still at a virtual phase, would ease the business processes. More generally, it allows Saks to take charge of some contextual conditions and relocate others' control to the customer. The employee-customer interaction (Bitner, 1992; Wilder et al., 2014) is partially replaced by an AR-customer interaction, controlled by Saks in terms of what is offered in-store versus what is available virtually for customers to select. The integrated smart glasses, with the ability to personalize and provide the means to choose and make a decision, further enhance the customer's touchpoints and for Saks to layout the aisles.

Table 17. Customer experience summary findings

Focus area	Key construct	Impact	Indicative empirical evidence
Org. - static	Contextual conditions	Customized and secure experience	"customized and secure shopping experience" along with "relevant information while they are shopping." (EVP, Digital Payments and Labs, Mastercard)
	Employee-customer interactions	Retailer employee interactions replaced by digital interactions in-store with enhanced engagement.	"ODG's smartglasses offer a hands-free, heads-up and body position independent form factor that gives users a richer, more immersive experience in AR," (EVP, Payment Partnerships, Mastercard) "This allows people to more fully engage with the world around them, on the go. This technology allows retail brands to engage with their customers in new ways—driving sales and bringing foot traffic back in store. It unlocks new ways for brands to reach and engage with consumers—to differentiate their brand, build loyalty and drive sales." (EVP, Digital Partnerships, Mastercard)
Org. - dynamic	Customer journeys	Addition of touchpoints, digitalization of touchpoints across shopping journey.	¨This new AR experience from Mastercard has enhanced the customer retail experience in many ways across the different touch points. It will not only let shoppers view digital representations of products before they commit to a purchase, but also learn more about what they are buying, see additional options not available in the physical location and get instant recommendations or other information relevant to their unique experience. When done shopping, users can pay for items using Masterpass, which will first authenticate the user's iris using Qualcomm Technologies' iris authentication. The shopper then selects a card from their Masterpass-enabled wallet and completes the purchase by selecting the Masterpass button on the screen. Items can be taken home from the store or shipped, depending on availability¨ (EVP, Digital Partnerships, Mastercard)
	Co-created experiences	Redistributes the touchpoints from one actor to another digitally.	¨The customer does not have to search for the products going around the store, waiting for the store employees to ask questions about the product, as well as don't have to stand in line to make payments or to carry them home.¨ (observation from study)
Consumer - static	Consumer-consumer influence	Introduces self service in physical stores	¨makes sense in a lot of ways but the reality is, we humans like to feel and touch. I personally won't buy a dress shirt unless I have felt the fit, the fabric quality and the button stitching. For items like T-Shirts it may not be as important so perhaps there are certain categories this would work for¨ (customer statement)
	Personal characteristics	Personalization could create privacy concerns with digitzed shopping journey	¨There could be privacy concerns due to the degree of personalization that is possible with the integrated smart glasses.¨
Consumer - dynamic	Sequential effects	Alters and makes less predictable the sequence of events - hedonic versus aesthetic or utilitarian reasons	¨Simply put, I like these smart glasses, and will likely own a pair as soon as they are available. The construction was very sturdy on the preproduction models that I demoed. They did not feel like they would break easily. The weight was great, and I could see myself wearing these for hours at a time without an issue. Heat issues aside, they felt great to wear.¨ (Reviewer of ODG smartglasses)
	Negative impressions	Possibility of new experience low's without retailer or producer awareness.	¨Aside from a couple of Bluetooth options and the ability to use your phone as a controller for both units, the only onboard controls were a small selection of buttons on the right side. I personally would find this at least a bit awkward, as one of the many left-handed people in the world. Maybe they will have a version with left-handed controls as demand increases for these products.' (Reviewer of ODG smartglasses)
	Waiting time	Enjoyment and hedonic experiences while shopping	¨Exploring is just part of the fun. Next comes combining and dressing! Once the shopper has found their outfit, they can dress the life size AR mannequin at the center of the space with their desired outfit¨(VP of Headworn, ODG)

Executive Vice President, Digital Partnerships, Mastercard said:

> "Mastercard sees additional opportunities to leverage AR and seamless payments to enhance the consumer experience in areas like home services. Imagine a home-decorating experience, for example, where you can design a room in your home and then close the loop on the entire process by enabling transactions right on the device. AR and AI will open new opportunities for both consumers and retailers, including creating a new world of real-time impulsive online shopping, allowing brands and retailers to even more accurately tailor offers and messages to consumers contextually¨.

Through the smart glasses, customers are given control over some contextual conditions. They can check how the different combinations of clothes fit, the price, and the clothes' brand before physically checking them out in the store. They can also influence the social experience by telling their friends and family that you don't have to go throughout the different aisles to check out the clothes, prices, and whether they will fit. The smart glasses being detached from an online store, however, means that Saks is not seizing an opportunity to engineer the social experience, for example, by providing customers using online or mobile channels the experience provided in-store by delivering an omnichannel experience.

The essential dynamic considerations include coherent customer journeys (Patrício et al., 2008; Wilder et al., 2014) and controlling the experience via multiple touchpoints in the customer journey while in-store (Akaka and Vargo 2015; Chandler and Lusch, 2015). With the smart glasses, Saks has ambitions that extend beyond the improvement of an isolated touchpoint and create different touchpoints that can enhance the customer journey. The aim is to move the first interaction with Saks to earlier in the customer decision-making process. Saks also sees the potential of extending the customer journeys with more touchpoints, as the integrated smart glasses encourage the customer to try out different combinations of products, see how they fit and understand whether the product is right for them, decide to purchase, make the purchase and choose the method of delivery

Executive Vice President, Digital Partnerships, Mastercard said:

> "ODG's smartglasses offer a hands-free, heads-up, and body position-independent form factor that gives users a richer, more immersive experience in AR. This allows people to more fully engage with the world around them, on the go. This technology allows retail brands to engage with their customers in new ways—driving sales and bringing foot traffic back in store. It unlocks new ways for brands to reach and engage with consumers—to differentiate their brand, build loyalty, and drive sales."

Saks identified the integrated AR smart glasses as an opportunity to move more customer media spending and their marketing-mix towards online. There is also a growing trend among shoppers to buy "outfits" rather than items, which has allowed upstarts like StitchFix, TrunkClub, Wantable, and MM.LaFleur to flourish. Executive Vice President, Digital Partnerships, Mastercard said, ¨This new technology will enable shoppers to create outfits with personalized recommendations pushed directly to them via iris scanning on the glasses."

The idea of iris authentication and biometric-based security is not new. It is something we have, as a society, seen throughout our lives on television and in science-fiction. Furthermore, while generally tied to underground government groups in these fictional works, there is a sense of familiarity with it. However, despite these familiar visions of the near future, the one area that remains a mystery in the new world of AR-as-computing-interface is security and how to protect these new AR users from hackers. In the wake of the hacks on Target, Home Depot, and Neiman Marcus, retailers are struggling to preserve their cash-register systems from malware looking to hack shoppers' credit card information. Executive

Vice President, Digital Partnerships, Mastercard said, ¨This experience makes payment and delivery more secure and seamless for both retailers and shoppers."

Founder and CEO of ODG said:

> ¨Just as individual brands have shifted a significant and growing portion of their media spend from traditional TV into mobile and digital advertising, AR smart glasses offer brands a new platform to reach consumers, in an even more contextual real-time way. We have heard from many marketing agencies and brands interested in developing unique, memorable consumer experiences at events, with our AR smart glasses as a first step in familiarizing themselves with the platform and its capabilities. We expect these activities to grow rapidly in the coming years. Retailers are starting to show interest in installing an experience like this Saks demonstration."

Reaching customers at an earlier stage of the decision-making process is also identified as an opportunity for Saks to bring the company closer to its customers by providing them the entire selection of the offered products. They can physically interact with the customers if needed, help with using the integrated smart glasses, validate their choices, and provide them a way to deliver what they decide to purchase. By engaging with customers this way, Saks has the potential to reduce the returns of products bought. However, this also puts light on the fact that Saks and the customer experience are co-created together with these integrated smart glasses. The consequence for Saks is that they are a luxury retailer with high-end products, and customers more clearly come into the store to touch and feel the product, and believe in engaging directly with the Saks store employees. Decision-making is based on the relationships of these interactions. This creates negative implications for the retailer for pointing the customer to integrated AR smart glasses. Saks could, however, use these smart glasses as a vehicle for enjoying the offerings and providing an aesthetic value for their customers before engaging directly with them on the selection and purchase of the products.

Consumer-level impact

The case demonstrated many positives in the integrated smart glasses, including the glasses' design, the controls provided, fast processors, authentication, and connection to the digital wallet. However, over time, there was no clear evidence of active use due to limitations of the glasses, heating, image quality, and privacy concerns affecting the solution being useful over time. From an aesthetic experience standpoint, the ODG R9 smart glasses using the Snapdragon 835 series were completely ordinary-looking from the front, much like sunglasses. They bulk up on the side because of the built-in speakers, the motion sensors, and a touchpad. But they are still very light and not bulky.

AR can enhance enjoyment values (Huang and Liu, 2014) by adding virtual information to real information and offering 3D pictures of products in different shapes, colors, and styles. Virtual objects and the information contributed by AR may heighten the user's enjoyment and mental imagery (Schlosser, 2003). AR, as system output interacting with the real world, creates the experiences of captivation and intuitiveness to enjoyment, inspiration, and creativity (Olsson et al., 2011). This Saks set-up allowed users to immerse themselves in an environment to enjoy the setting without having to walk around the store looking for products, pricing, and fitting.

The consumer-level perspective of customer experiences focuses on consumers' perceptions of customer experiences (Kranzbühler et al., 2018). Table 18 summarizes the findings on consumer perceptions of customer experiences. The static factors influencing consumer perceptions include other consumers being present at the time of the experience (Chen et al., 2009; Kim and Lee, 2012).

Says a customer:

> ¨Given Saks is a luxury retailer with high-end clothing, the integrated AR smart glasses retail experience makes sense in many ways, but the reality is, we humans like to feel and touch. I personally won't buy a dress shirt unless I have felt the fit, the fabric quality, and the button stitching. For items like T-Shirts, it may not be as important, so perhaps there are certain categories where this would work.¨

The digital world brings dramatically more possibilities of these interactions and influences the perceptions of customers.

This case was to understand the ease of use and perceived usefulness of the AR design. The goal was to build a lightweight, high field vision, high speed, high battery life design for consumers to find the set-up easy to use. Issues were identified in the projection device and the data provision. While the intent was to provide a frictionless integration between the capabilities, the customers did not perceive it as easy to use. The handshakes were not seamless for active use – the glasses were not meant for people who already wore glasses, and there was friction in the integration between what one could see via the glasses and the real world, limited by network bandwidth. There were also privacy concerns around being authenticated. Both usefulness and perceived ease of use are factors that influence whether consumers will maintain a loyal relationship and engage in active use behavior with interactive technology (Chiou and Shen, 2012). Therefore, usefulness and perceived ease of use can be seen as the most critical factors that encourage consumers' active use of AR smart glasses.

Aesthetics can be controlled through design, color, virtual reality, and vividness (Mathwick et al., 2001). The entertainment value comes from consumers' enjoyment of the shopping experience (Babin et al., 1994). The smart glasses provide an aesthetical experience by delivering visual appeal and entertainment and create an environment that facilitates the smooth accomplishment of consumers' specific shopping tasks. It is the most critical factor to ensure the consumer maintains and invests in a relationship with the retailer that employs AR. The smart glasses with field vision, voice controls, and high-speed processor provided the technology enablement for users to experience the immersive environment.

A reviewer of ODG smartglasses, when asked whether the ODG R9 smart glasses with the integration were enjoyable, said:

> ¨Simply put, I like these smart glasses, and will likely own a pair as soon as they are available. The construction was very sturdy on the preproduction models that I demo-ed. They did not feel like they would break easily. The weight was great, and I could see myself wearing these for hours at a time without an issue. Heat issues aside, they felt great to wear.¨

The integrated smart glasses have possibilities for how the users can combine this experience and fulfill the shopper's taste. It was summed up well by VP of Headworn, ODG, who says:

> ¨Exploring is just part of the fun. Next comes combining and dressing! Once the shopper has found their outfit, they can dress the life-size AR mannequin at the center of the space with their desired outfit. You can envision future releases enabling the ability to select from a vast array of different mannequins that can reflect the individual shopper's body shape and dimensions.¨

Though the set up was exciting in terms of possibilities for how users could indulge in it, without logging in online, using passwords to authenticate, or using different devices, the level of maturity to provide seamless and frictionless delivery was not realized. Problems were primarily due to heat issues, image quality, frameset size, and the controls being made only for right-handed people.

The dynamic side of the consumer perspective focuses on key events in the customer journey and how they implicate the experience (Ross and Simonson, 1991; Verhoef et al., 2009). The smart glasses transform the customer experience's events by moving the interaction with the products virtually in-store even though they are physically available in the aisles to touch and feel. The integrated smart glasses introduce new events that may stand out as extreme events and reshape the retail environment, making it more immersive and efficient.

This unique AR experience from Mastercard has enhanced the customer retail experience in many ways across the different touchpoints. It will let shoppers view digital representations of products before committing to a purchase and learn more about what they are buying. The users can also see additional options not available in the physical location and get instant recommendations or other information relevant to their unique experience. When done shopping, users can pay for items using Masterpass, which will first authenticate the user's iris using Qualcomm Technologies' iris authentication. The shopper then selects a card from their Masterpass-enabled wallet and completes the purchase by selecting the Masterpass button on the screen. Items can be taken home from the store or shipped, depending on availability. First visualizing the products and try-on for fit and comfort creates an initial enhanced retail customer experience. The customer does not have to search for the products by going around the store, waiting for store employees to ask questions about a product, or standing in line to make payments or carry products home. A luxury brand like Saks with these trendy integrated AR smart glasses allows customers to explore possibilities and options to self-serve in-store as they would do on mobile or online, while also checking the physical products. AR has brought about the opportunity of virtual objects in a physical store.

The same users do not frequent the set-up in a high-end store for day-to-day product selection and purchasing. This affected active use of the technology at the outset. The technology enablement and the way the data was provisioned negatively affected how customers interacted with the AR.

Practice Lead, Mastercard Labs R&D responded as follows:

> ¨The technology is not ready for mass adoption, which limits practical applications in the current marketplace. There could be privacy concerns due to the degree of personalization that is possible with the integrated smart glasses.¨

Conversely, integrated smart glasses also can create events that stand out as negative experiences (Sivakumar et al., 2014; Tax et al., 1998). On the active use of the integrated smart glasses, the Reviewer of ODG smartglasses states:

> ¨Aside from a couple of Bluetooth options and the ability to use your phone as a controller for both units, the only onboard controls were a small selection of buttons on the right side. I would find this at least a bit awkward, as one of the many left-handed people worldwide. Maybe they will have a version with left-handed controls as demand increases for these products.¨

Given the high-end products at this luxury retailer, customer expectations may not be met by being asked to use the smart glasses. They may walk away without interacting with the in-store employees or checking the physical products, and perceive the interaction as negative.

An active developer and one who studied these ODG smart glasses, amongst others, said:

> ¨The form factor of the R-9 is too small to wear with a pair of glasses. It makes it hard for people already wearing glasses to use this for a long time …… the field of view did not feel as tall as the other devices I have used.¨

This case applies the theoretical framework in an in-store retailer to demonstrate how the AR characteristics of information level, interactivity and quality of augmentation can enrich the retail customer experience from an organizational and customer level standpoint. The experiences were based on the intent of the retailer to create a differentiated customer experience in terms of personalization, digital interactions, control and different touch points in the customer's shopping journey as well as the customer's perceptions for how they engaged with the smartglasses based on their knowledge and comfort for the integrated solution could provide.

4.2 Case 2: Mobile AR and Retail Customer Experience in Retail - LP[15]

This case examines the use of a mobile AR app and its characteristics and its effects on customer experience improvements in retail. This case's core was completed by two CBS Master's degree students as part of their thesis and is a key contribution to the doctoral thesis to understand how an AR app could augment customer experiences. This case investigates how the AR app commissioned by the Danish designer house Louis Poulsen (LP) affects customer experience in retail. The case shows that AR provides possibilities to engineer the conditions influencing customer experiences and redistribute control of touchpoints in the customer journey. Consumers' perceptions of the experience are exposed to a widening of the consumer-to-consumer influence, changing demographics, new event sequences, and a less manageable approach to service recovery. These effects are contingent causalities where the effective harnessing of AR's experience-enabling capacities requires a profound transformation of the existing structures by which customer experiences are formed.

The Danish lighting manufacturer was founded in 1874 in Copenhagen, Denmark, and employs approximately 270 people globally. LP offers its lighting solutions to both B2B and B2C customers, for both indoor and outdoor purposes. LP has, through the years, had some of the most famous Danish designers, such as Poul Henningsen and Arne Jacobsen, working for them. Through these close partnerships, "LP has succeeded in establishing itself as a significant architectural and decorative lighting supporter. Additionally, LP has managed to obtain a global presence with showrooms and shop-in-shops

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[15] Appendix 1 **Paper 3:** Henningsson, Stefan; Vaidyanathan, Nageswaran; Archibald, Philip; and Lohse, Mark, "Augmented Reality and Customer Experiences in Retail: A Case Study" (2020). AMCIS 2020 Proceedings. 18. https://aisel.aisnet.org/amcis2020/strategic_uses_it/strategic_uses_it/18

worldwide" (Visual Concept and Merchandising Manager). LP positions itself as a premium brand with a high price and high value within the market. "We are premium positioned, so we are high price and high value positioned. We are also quite in terms of brand value, emotionally positioned in terms of next to having high product quality also has a great deal of ambiance and legacy to our products." (Brand Communications Manager).

Moreover, the Brand Communications Manager also explains that the further away from Denmark the brand is exposed, the more exclusive it is perceived. However, Danes have a tradition of being big spenders when it comes to interior design (Ibid). Having a premium position brand narrows down a demographic group to 30-50 percent of the population that, at some point in life, will be willing to pay up to $1000 for a dining table lamp (Ibid). LP has identified their core segment as people in the age group 45-65 years old with high income, long-term education, and interest in design and interior.

Many reasons shaped the decision for LP to invest in AR technology as a medium for expressing their core values: Design aesthetics and quality of light. The expectations of what this new add-on feature will add to their current marketing mix are modest due to the technology's novelty. The application offered by LP is a go-to-market-ready application. The Brand Communications Manager says: [...] "We are hoping to sell more for it to be justified, and to be more than a pleasant brand experience." [...] (Ibid).

Louis Poulsen has identified some business areas and processes that they believe can be enhanced and made easier using AR technology (Ibid). Firstly, they looked to see if AR could be more than just a gimmick and be a valuable business tool to increase sales and make internal business processes more manageable. LP identified some business processes that AR could potentially enhance. "We can see that] the pace of product launches, patience to getting access to products and complications of moving physical products are a struggle for our sales consultants, our logistics and manufacturing" [...] (Ibid). By introducing AR earlier in the customer decision-making process where the products are still at a virtual phase, it would ease the business processes. Reaching customers at an earlier stage of the decision-making process is also identified as an opportunity for LP to bring the company closer to its customers. Secondly, LP identified AR as an opportunity to move more customer media spending and their marketing-mix towards online. "This is yet another feature or tool or the possibility that makes online more relevant and will be yet another asset to move spending in that direction" (Ibid). Lastly, by introducing lower priced items, LP tries to lower the entry-level for customers and expand their target audience (Ibid). The investment in AR moves towards this direction and is identified as a possibility to reduce the age segment.

The Markerless AR application allows customers to augment reality by placing virtual objects, in this case three of the classic LP lamps, into real-world surroundings (Virsabi, 2018). It enables customers to see how a specific lamp would look in their homes. The customer then can move the lamp around to see how it fits (e.g., their current dining room table or if it looks good next to their couch). Essentially, it allows for customers to walk through their living room, experiencing the design craftsmanship at close range and seeing how it would look like in their environment (Ibid).

There are certain features implemented in the application to increase the customer experience. Firstly, there is the ability to adjust the cord's length on the lamps, making it possible for customers to experience a more realistic impression of how it would look. A standard length on cords would not take the different heights of ceilings into account and shatter the illusion of the lamp being there. Secondly, the customers can adjust the lamp's color and size to make sure they can see exactly what the desired product would look like (Ibid). According to LP, the application's intuitive interface design makes it easy for anyone to use it, and it does not require an advanced degree of technology to get started (Ibid). The intuitive design makes it easy to navigate. It is not filled with unnecessary features that would alter the focal point, which is that customers experience the materials and designs at close hand (Ibid). Figure 9 is a visualization of how the LP AR application looks.

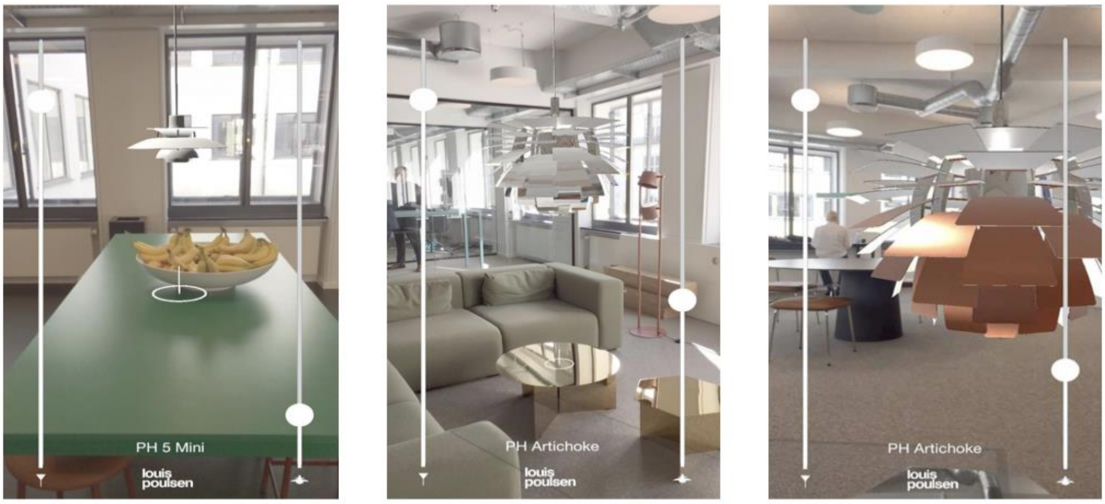

Figure 9. The LP mobile AR app

Mapping the case to the theoretical framework

AR characteristics and how they impacted the retail customer experience

The case reveals that AR's characteristics (interactivity, information level, quality of augmentation, and integration with other value-added services) are critical in how AR enriches and affects the LP customer experience. This app had much promise. However, each of these characteristics must be improved if the customer is to engage with the app, and the retailer can connect the touchpoints in the customer journey more effectively. The quality of augmentation was not good enough for the customers to know whether what they saw on the app was sufficiently realistic in terms of color and lighting and how it would fit what they were looking for. The information level was not enough to understand the size, price, or brand effectiveness clearly. The lack of integration to key company processes was also an area to improve. Table 18 below summarizes the impact of the AR characteristics and also highlights key evidence from the interviewees.

Table 18. Summary of findings - AR characteristics and impact on the retail customer experience with the LP markerless mobile app.

AR characteristics	Description	Indicative Empirical evidence
Information level	Bottom-up and top-down content	"I also believe that I would take more risks by purchasing a lamp because you fall in love with the lamp that fits really good in the corner" and "It might be safer to buy. If it works optimally, then it may also be faster because you do not have to ask all the questions you actually got an answer to." (Customer 1, Customer 6). "You might also be able to borrow it home. It is a bit the same but that you want to be able to see how the lamp looks in your own home." (Customer 6), "But I just felt that there could have been a bit more text that could enrich my knowledge on more than just how they look." (Customer 4)
Quality of Augmentation	Realistic overlays of 3D objects in the physical world	"Yes, I would really like for the application - instead of just standing there with it on your phone - to have a decent screen size, a screen size people can relate it to." (Head of Lighting Department, Illums Bolighus), "I had a hard time getting the lamp to show and figuring out how you move it somewhere else" and [...] "Assuming it has to be plug-and-play it has to be easy to go about, and this was a bit a hassle" (Customer 3), "Is it the right size compared to the picture? And what is the design like? What is it inspired by? More information about that. Neither does it say how tall and low the lamp is." (Customer 8) ¨I have here? I expect it to be - but I don't know. And I'm afraid if I see the final product that it's actually a different size. I might have saved it wrongly, so it should be automatic." (Customer 6),
Interactivity	Utilities (search, narration, content, need for touch), connectivity (social features), entertaining attributes (look and feel)	"We are a number of people that often visit our customers, and if we could bring along a tool like this, there is no doubt that it would be a tremendous help." (Head of Lighting Department, Illums Bolighus), "Maybe if people sit at home playing with it, then they can become 'hooked' to that specific lamp. It can emancipate their expectation to what people desire." (Owner at Vestergaard Møbler), "My gut-feeling says its 80% of the items that are home-tested are converted into a sale... [...] Generally for Louis Poulsen products is a relatively high turnover and very few returns." (Head of the Lights Department, Johannes Fog), "Otherwise, I think it's cool that I don't need this personal guy that comes to my house because I can see the lamp myself in my home" (Customer 5) "I definitely think it is personal because you can see it in relation to your own stuff rather than in a store" (Customer 3)

This case addressed the organizational and customer-level static and dynamic constructs of the theoretical framework from a customer experience standpoint

Organizational level impact

The static and dynamic impact of the AR app on the organizations' creation of customer experiences (Kranzbühler et al., 2018) is summarized in Table 19. The relevant static influences that organizations can address include contextual conditions and employee-customer interactions. For contextual conditions (Mathwick et al., 2001; Surprenant and Solomon, 1987), LP seeks to control the physical retail experience by its in-shops strategy. LP is too small to have its own retailer network, but the in-shops carry the lamps' aesthetic design. However, it is beyond LP's reach to control environmental conditions such as sound, smell, inventory levels, and social stimuli. LP has furthermore limited possibility to control the employee-customer interaction.

Table 19. Customer experience summary findings

Focus area	Key construct	Impact	Indicative empirical evidence
Org. - static	Contextual conditions	Increased control over contextual conditions/Customer empowerment of contextual conditions.	"We can see that the pace in product launches and patience to getting access to products and complications of moving physical products is a struggle for our sales consultants, for our logistics and manufacturing" [...] (LP Brand Communications Manager).
	Employee-customer interactions	Retailer employee interactions replaced by digital interactions.	"So that if we can help the decision process at an earlier stage where we are only dealing with virtual products it would be an immense help for both the selling process." (LP Visual Concept and Merchandising Manager).
Org. - dynamic	Customer journeys	Addition of touchpoints, uncoupling of touchpoints.	"This is yet another feature or tool or possibility that makes online more relevant and will be yet another asset to move spending in that direction" (LP Visual Concept and Merchandising Manager).
	Co-created experiences	Redistributes the touchpoints from one actor to another.	"Sometimes you can go in and ask for a product and they try to sell you something else." (Customer 6).
Consumer - static	Consumer-consumer influence	Introduces new channels for customer-customer influence.	"…[I]t would probably through blogs, social media and through influencers." (Customer 1)
	Personal characteristics	Personalizing of experience and potentially new customer demographics.	"I definitely think it is personal because you can see it in relation to your own stuff rather than in a store" (Customer 7).
Consumer - dynamic	Sequential effects	Alters and makes less predictable the sequence of events.	"I think the possibility of being allowed to do that would make me more likely to buy it and I think I would be more pleased with the product" (Customer 7).
	Negative impressions	Possibility of new experience low's without retailer or producer awareness.	"Of course, they must be easy to get in touch with. If it suddenly gets too cumbersome to purchase something, then it can actually decline, for me at least" (Customer 2).
	Waiting time	New possibilities to entertain customer during a wait.	"Then I can suddenly sit and play around with their products and it gives me engagement combined with the fact that it is in my own home." (Customer 4).

The AR app has the potential to increase LP's control over the factors influencing the customer experience. Inventory management is one such parameter that is specifically targeted. By introducing AR earlier in the customer decision-making process where the products are still at a virtual phase, it would ease the business processes. More generally, the AR app allows LP to take charge of some contextual conditions and relocate the control of others to the customer. LP's AR-customer interaction partially replaces the employee-customer interaction (Bitner, 1992; Wilder et al., 2014). The replacement is only partial, as the AR app is not fully integrated with online sales channels and customer service. From a customer experience perspective, this would have given LP more possibilities to engineer the experience.

Through the AR app, customers are given control over some contextual conditions. They can examine the lamp at home and be in charge of lighting and sound. They can also influence the social experience. They can show the lamp to friends and family to get approval. However, since the app is not integrated with social media, social stimuli require physical co-location. Because the app is decoupled from social media and online stores, this also means that LP is not seizing an opportunity to engineer the social experience, for example, by pointing to customers or customer-relevant influencers that have praised the design of the lamps.

The essential dynamic considerations include coherent customer journeys (Patrício et al., 2008; Wilder et al., 2014) and controlling the experience across retail partners (Akaka and Vargo 2015; Chandler and Lusch, 2015). With the AR app, LP has ambitions that extend beyond the improvement of an isolated touchpoint and create a new touchpoint that can change the customer journey. The aim is to move the first interaction with LP to earlier in the customer decision-making process. LP also sees the potential of extending the customer journeys with more touchpoints, as the AR app encourages the customer that has seen an LP lamp in a store to virtually take the product with them and try it out at home. LP identified AR as an opportunity to move more customer media spending and their marketing-mix towards online.

Reaching customers at an earlier stage of the decision-making process is also identified as an opportunity for LP to bring the company closer to its customers. However, this is also putting light on the fact that LP's customer experience is co-created with retailers. The consequence for retailers is that customers come into the store, specifically looking for the LP lamp. This moves some of the power in the relationship between LP and the retailer in favor of LP. More importantly, the AR app may also move the closure of the sale from the retailer to LP's online store. Therefore, there are currently only negative implications for the retailer for pointing the customer to the app.

Consumer-level impact

The consumer-level perspective of customer experiences focuses on consumers' perceptions of customer experiences (Kranzbühler et al., 2018). Table 19 summarizes the findings on consumer perceptions of customer experiences. The static factors influencing the consumer's perception include other consumers being present at the time of experience (Chen et al., 2009; Kim and Lee, 2012). When customers start to use the app, they can receive input from other virtual shoppers on social media. The consumer-level side of this possibility refers to the uncontrollable influence that other customers can have through their reviews and social media posts. The digital world brings dramatically more opportunities for these interactions and influences. One customer's poor experience that traditionally would stay in the store can now be documented online and reach millions of potential consumers in a blink. LP's prospective customers recognized this possibility, declaring that the AR app would increase the impressions from other customers. Both LP and retailers recognize that they also catalyze consumers' empowerment to influence each other in this way.

The personal characteristics (Holbrook and Hirschman, 1982) that link to the perception of LP's AR-mediated customer experience include the consumer group's demographics. LP expects that the AR app will change the customer base's demographics towards a younger clientele that shares the interest for interior design, but for whom the lamp's price is a sizeable investment. For this group, the AR app's quality to visualize the product at home reduces purchase risk. While allowing for a more personalized consumption process, LP's AR app also gives another opportunity to target a specific subgroup. The purchase of an LP lamp is a very substantial investment. Because there is a limited possibility to try out a lamp fitted over the dining table at home, the app is considered to deliver a more personal experience: "And since the lamps are quite expensive, I think it would be a good idea if you were able to see them at home beforehand." (Customer 2) But it is important to stress that this is a quality that suits some consumers, not everyone: "For me, it would work better to go down to the store and be able to see the lamp physically in front of me." (Customer 8)

The consumer perspective's dynamic side focuses on key events in the customer journey and how they impact the experience (Ross and Simonson, 1991; Verhoef et al., 2009). The AR app introduces new events that may stand out as extreme events. Being able to visualize the lamp at home is seen as a possible high that can determine the whole experience: "Yes I think so. Again, it enables one to go and fall in love with a lamp when you have the opportunity to see it at home." (Customer 3). A brand with an AR app has an advantage over its competitors: "If you have a similar company with the same expensive lamps and compar[e] them against Louis Poulsen, […] [t]he decision-making process would be far easier by Louis Poulsen than the other company …" (Customer 6)

Conversely, the AR app also can create events that stand out as negative experiences (Sivakumar et al., 2014; Tax et al., 1998). An issue raised was uncertainty about whether the lamp was correctly represented in the AR app: "The lamp in itself is realistic, but from the perspective I'm viewing it from, is it then the right size compared to the distance I've got the table. That I don't know." (Customer 7). Another issue was the lack of rich information about where to buy the lamp, inventory, makes and materials, etc.: "Maybe I did not discover all the features, but it did not seem as if there was that much information." (Customer 4).

Another way the AR app transforms the events of the customer experience is by moving the interaction with the lamp spatially from the retailer's premises to the consumer's home. At the store, the staff would be able to counter negative experiences. When using the app, LP and the retailer are not aware of any negative experiences. Because there are limited channels to connect to LP when using the app, consumers said they might simply walk away from the product.

The case applies the theoretical framework in a mobile retail setting to demonstrate the impact of the AR characteristics on the customer experience from organizational and customer level standpoints and addressing both static and dynamic constructs. This case shows how the firm creating the lamps provided control and optionality for customers to search and look for fit of lamps in their individual homes via digital intertactions and differentiated touch points in their journey. It provided possibilities for competitive differentiaition, removing intermediaries and interacting with customers directly. From a customer perception of the experience, they could interact virtually with the different lamps to understand how they could experience the presence of these lamps in their own homes.

4.3 Contrasting the Cases

The underlying theoretical framework used in both of these cases demonstrates that the AR characteristics can enrich retail experience within the environment of the traditional in-store and in mobile formats. Overall the retailers and customers were satisfied and impressed with the potential for this technology. The AR characteristics in each case had an individual and collective impact on how to enrich the retail customer experience both from how the retailer set it up and how the customers experienced it. The framework can be used for future research to explain the AR characteristics and how they could affect customer experience. The Saks case demonstrated certain factors that could extend the framework. These factors included privacy concerns and their effect on the experience, and how integrating different digital technologies should be considered. The other considerations include demographic and cultural dimensions of customer experience, as demonstrated by the LP case using a mobile AR solution. It needs to be understood how to make the solution acceptable for other age groups and types of customers who want to engage with the retailer in-store versus mobile. Both studies demonstrated the need to consider the framework from a marketing, branding, and loyalty angle. This was evident because both LP and Saks 5th Avenue are high-end retailers serving a specific demographic group where the customers are typically engaged and loyal to the underlying brand.

The retail customer experience can be augmented in a physical retail store enhanced by innovative and immersive AR technologies (Verhoef et al., 2009). Here, the customer's current perception of the real store space, the environment, and the shopping experience is mediated and enhanced by AR that consumers explore and naturally interact with while in the physical store or online (Hilken et al., 2017). AR thus extends the traditional and real physical retail space boundaries surrounding the customer (such as the store's physical limits, the items physically present in the store, the information at consumers' disposal and the way it is provided, and the ability to make decisions). Here, consumers' natural interactions with the store environment through innovative and realistic interfaces, space mobility, and visibility constitute a key feature (Bonetti et al., 2018). It offers new possibilities to see and interact with virtual objects not physically available in the real store space, enriching content, thereby leading to consumers' deeper participation and helping to confer a richer and more immersive perception of the store environment. It provides a shopping experience, entertainment, and enjoyment in the real physical store (Bonetti et al., 2017).

The Saks case has explored the integration of AR techniques with other technologies within a physical store and has suggested ways to develop a new store form, the augmented store, by making the store enriched, enhanced, more accessible, entertaining, and efficient for consumers (Bonetti et al., 2017). Results showed that participants perceived the new augmented store to be more immersive, entertaining, engaging, and enjoyable. It extends the extant literature on augmented and immersive places (Carmigniani et al., 2011; Chang et al., 2015; Oleksy and Wnuk, 2016) to a specific real-world context of the retail store by providing knowledge on the shift towards an AR in-store and on what AR provides for the retailer and its customers. The LP case on the other hand demonstrated that the integration in an online and mobile format is important to share peer feedback, understand other’s views on the experience as well as enable retailers to integrate with their own internal applications.

The Saks case also contributes to the existing literature on Human Computer Interactions (Kjeldskov and Graham, 2003; Rogers, 2004) by focusing on consumers' interaction with the technology (consumer-computer interaction or CCI), thus extending existing research on a generic user's interaction with technology in a generic place. In particular, the case focuses on consumers' interactions with AR technologies in an actual store's real-world context. It extends previous research conducted in simulated and controlled laboratory environments with simulated consumers (Pantano and Laria, 2012; Pantano et al., 2017; Papagiannidis et al., 2017) by investigating perceptions of current actual consumers of a retailer, their interactions with immersive AR technologies in a real, physical retail store, and their reactions to the new and enhanced store space and environment.

Furthermore, this impact study has implications for practitioners. It unveils positive consumer reactions to the augmented store form, providing practitioners with a new perspective on a specific new technology to be successfully integrated within traditional sales points. Retailers willing to further engage with customers by enhancing their in-store experience should, therefore, consider types of immersive technologies, where these can provide entertaining, informative, and engaging experiences (Hilken et al., 2017).

The two cases looked at different perspectives on how AR could address retail experience challenges. The Saks case was based on an in-store setting using AR smart glasses with integrated value-added services for authentication and using a digital wallet to make purchasing decisions. By contrast, the LP case used a mobile AR app to enable customers to understand how lamps would fit in their homes and provided a sense of ownership, control, and purchase decision making. In the first case, the retailer challenges tested related to the product offering, how they were stocked in the aisles, try-outs, selection, payment lines, delivery method, and reduced returns. The LP case was about online customer experience, and the goal was to reduce the distance between physical and online experiences. The LP case also provides the retailer with options for inventory management, changing the supply chain and handshakes, and developing a servicing ecosystem with customers and the retailer in direct contact (Verhoef et al., 2009). It also addresses the reduction in returns as the lamp was tried virtually in the home setting.

The cases showed the relevance and potential for AR, both in-store and online (Hilken et al., 2017). Several existing retailer experience challenges could be addressed by integrating other services or designing AR based on shopping journeys for customers. There are still many obstacles to be overcome, including ensuring the retailer and customers are engaged upfront in the AR's design and development to make the most sense of what specific utility or task or outcome is being addressed. The new technology and other digital technologies should be looked into together to improve or change retailer business operating models to meet retailer goals and objectives (Poushneh and Vasquez-Parraga, 2017).

Although both cases take a qualitative approach, the Saks and LP cases' findings could be used to link consumer perception to purchase behavior. For example, by exploring whether consumers spend more time in-store due to an enhanced experience, or whether it influences purchase intention, and whether this applies online or not. Finally, future research could investigate managerial perspectives of consumers' reactions to and perceptions of stores enhanced with AR technologies, both in-store and online. Retail experience depends on a mix of established and emerging technologies, but the cases demonstrate that AR can impact the experience for the retailer and the customer and is being adopted by industry and consumers alike (Verhoef et al., 2017; Grewal et al., 2017).

AR should be less about technology doing things to people and more about people engaging with the world around them and having that world enhanced by technology where and when appropriate. This would ensure that the solutions built using AR would map to what the users need and expect as retail customer experience when they traverse the different touchpoints in the shopping journey. The type of device and setting should make sense for the environment. The solution should create an integrated experience amongst the different digital or physical actions that retailers and customers need to take. Other topics that the two cases pointed out were concerns around privacy, the safety of using the devices while in-store, and not being able to visualize the size and positioning of the products away from the physical store.

The impact of the AR characteristics of interactivity, quality of augmentation, and information levels on both the retailer and the customer is identified by how these characteristics impact each construct at organization and customer levels in each case (Table 17 and Table 19). Each of the retailer and the customer's impacts is summarized from the Saks and LP study (Tables 20 and 21).

Table 20. Summarizing the impacts of the two cases on the retailer experience.

Impact ID	Impact Description	Saks Study	LP Study
RE1a	Personalized and Secure	X	NA
RE1b	Increased control over contextual conditions/Customer empowerment of contextual conditions.	X	X
RE2	Digital Interactions	X	X
RE3a	Integrated Digitalized touchpoints	X	NA
RE3b	Additional touchpoints, uncoupled	X	X
RE4	Redistribution of touchpoints	X	X

- RE1 (RE1a and RE1b) – Personal and contextual control – this combines the specific impacts in each case to demonstrate that AR can impact retailers by providing customers personalized and contextual control while interacting with AR.

- RE3 (RE3a and RE3b) – Uncoupled digital touchpoints – this combines the specific impacts in each case to demonstrate that AR, both as standalone as well as when integrated with other technologies, provides retailers opportunities to offer different and uncoupled touchpoints in the customer's shopping journey

Table 21. Summarizing the impacts of the two cases on the customer experience

Impact ID	Impact Description	Saks Study	LP Study
CE1	New channels	X	X
CE2a	Personalization	X	X
CE2b	Socio-demographics	NA	X
CE3	Shopping journey events	X	X
CE4	New experience	X	X
CE5a	Enjoyment and Hedonic experiences	X	NA
CE5b	New possibilities	NA	X

- CE2 (CE2a and CE2b) – Personalization – the cases demonstrated that customers experienced a personalized interaction with the AR technology in their shopping journey. In the LP case, there was an additional intent to expand to other customer demographics using AR.

- CE5 (CE5a and CE5b) – Varied purposes – in the Saks case, AR was used in the waiting time or otherwise to provide for the enjoyment and hedonic experiences as part of the customers' journey. In contrast, in the LP case, varying entertainment experiences were offered to customers while interacting on their mobile app.

4.4 Deriving the Conceptual Model

The Saks and LP cases demonstrated the AR technology design attributes and retailer and customer attributes that affected how customers experienced the AR characteristics.

4.4.1 AR technology design attributes

A critical concern in AR is performance speed and the vividity or level of augmentation, as experienced by users in the LP case and the Saks case. Low-performance speed prevents the use of AR technology in real-time applications. The rendering approach depends on the application area. In retail, the goal is to create a realistic scene by embedding virtual objects with photorealistic rendering.

AR is an area where photorealistic rendering is appreciated; dimensional accuracy is also crucial when deciding whether a piece of furniture fits in an existing space as highlighted by the LP case. Business factors – number available, models, and brands – are within the control of the owner of a commercial application. It is also the retailer's role to implement adequate search functionalities and create realistic 3D models, so the user feels the sense of interaction to make decisions.

The key AR technology design attributes (from chapter 3) affect the use of and engagement with the AR characteristics in both in-store or mobile settings. These are summarized in Table 22 below.

Table 22. How the study experienced the AR solution design

AR Technology design attribute	Saks Study	LP Study
Display	Smartglasses were clunky, not built user friendly	Mobile AR, easy to use
Format	In-store with luxury retailer caused employees to be left out of the journey experience	Mobile, provided options to view lamps and how they may fit at home
Rendering	Felt loss of touch and feel due to quality of images and type of clothing	Quality of images in terms of height and size unclear
Standalone or Integrated	Key services integrated but was not frictionless, also created privacy concerns	Not integrated, retailers and customers needed integration to internal apps and social media given this is mobile

There are similarities and distinctions in the two cases when their experiences are analyzed against the key organizational and customer level attributes.

4.4.2 Retailer attributes

For the user, a good experience consists of comfortable and pleasant use of the application and satisfying results. For the retailer, good customer experience means that the solution is easy to deploy and supports the business goals (Väänänen-Vainio-Mattila, Oksman, and Vainio, 2007). In other words, the AR solution needs to be valuable to the user, in addition to being useful, usable, and desirable (Morville, 2004).

Saks is a high luxury apparel retailer on 5th Avenue, NYC, where the integrated smart glasses were used to enhance customer experience by providing its customers an option to self-select products, make a purchase decision, and determine delivery options. Saks wanted to provide competitive differentiation via immersive technologies and chose integrated smart glasses to understand the impacts. In the LP case, a high-end lamp manufacturer in Copenhagen, Denmark wanted to create competitive differentiation by providing its customers an option to make lamp choices from the comfort of their homes, determine the fit, and have the ability to purchase. The AR app was not integrated though it affected the shopping journey touchpoints. LP also wanted to create a new channel for interacting with customers directly, versus via retail stores.

The retailer attributes uncovered in the cases were store formats, type of store, and differentiation from competitors online or in-store, as summarized in Table 23.

Table 23. Retailer attributes identified by the cases

Retailer Attributes	Description	Saks Study	LP Study
Store Fronts	Physical, mobile, online, multi, or omni	Physical in-store	Mobile
Type	Luxury, commodity	Luxury apparel retailer	Luxury lamp manufacturer
Competition	Other similar options for customers	Competition with online shoppers as well as other luxury brand apparel retailers	Competiton with online shoppers as well as intermediaries and other lamp retailers

4.4.3 Customer attributes

In the LP and Saks study, users were involved in testing visual perception issues and AR performance as well as in developing interaction techniques and user collaboration (Swan and Gabbard, 2005; Shen, Ong, and Nee, 2010).

The Saks case, via its integrated smart glasses at Saks 5th Avenue, showed that it was necessary to clarify customers' reasons for using the technology – enjoyment, aesthetics, or making a purchase. Given Saks is a luxury retailer, the customers came here typically to touch and feel the products and have interactions with the sales employees before making a purchase. Relevant factors included the customers' socio-demographics, brand, and price, and how customers wanted to engage with the smart glasses to make decisions. In the LP case, the mobile AR app was used from the comfort of their homes to understand how the lamps would fit in their homes and what intensity of light they provided. It catered to a specific socio-demographic group given the high-end brand of the lamps. In this case, the interviewed customers provided the insights that they did want to physically interact with the lamps before making a purchase given the price and brand; however, they were willing to experience this from home. They wanted to engage with the technology to understand options. Additionally, the customers were involved in what other customers thought about this technology, and they wanted to access social media from the app.

These cases provide context for the customer attributes that influence the perception of the experience. The attributes identified in these cases from a customer perspective are summarized in Table 24.

Table 24. Customer attributes identified by the cases

Customer Attributes	Description	Saks Study	LP Study
Goals	Hedonic, Aesthetic or Utilitarian	The integrated smartglasses were used to enjoy and have fun as well as for making a purchasing decision	Understanding how the lamps would fit at home and trying options
Socio-demographics	Age and gender and social status of customer	Luxury retailer where customers wanted to touch and feel in the physical store	LP was trying to use the app to attract a different demographic while customers wanted to touch and feel before making purchase
Attitude	Price sensitivity, Innovativeness, Involvement	Being high end, customers wanted to interact with store employees while they tried out the smartglasses for enjoyment and fun	The customers were willing to engage and try out options, wanted to do peer reviews as well as integration to social media

These attributes point to several reasons for why a design focus to develop AR solutions is needed. In AR, the development has been technology-driven, and only recently have there been more user-centric approaches (Swan and Gabbard, 2005; Dünser, Grasset, et al., 2007).

The purpose of using AR is to aid the user in a meaningful way. Users find it important that they know what is happening and feel that they control the system. Individuals have different preferences regarding how they wish to interact with the system. By providing the customers the level of information they need, they feel in control and will accept and adopt the technology.

The findings align with human-centered design principles, indicating that the result is generalizable for different AR applications (Chapter 5). Users have different expectations for a system; the first-timers or infrequent users prefer an easy-to-use and simple system; the professional user desires more features and interaction options. These kinds of expectations could be fulfilled by giving the user an option to select the way of interaction with the system via personalization or preferences (e.g., different user interface options). The system should support the purpose for which it is used. Users often have high expectations, and the number of desired features can be increased. Therefore, it is essential to identify "must-have features" and solve bottlenecks that would prevent or hinder the use of the AR solution.

4.4.4 Proposed conceptual model

The conceptual model that brings together the impacts of AR to the retailer and customer (from Chapter 3), the different attributes of the retailer and the customer (sections 4.4.1, 4.4.2, 4.4.3) as well as the impact mechanisms of AR on the retailer and customer (Tables 20 and 21) is depicted below (Figure 10).

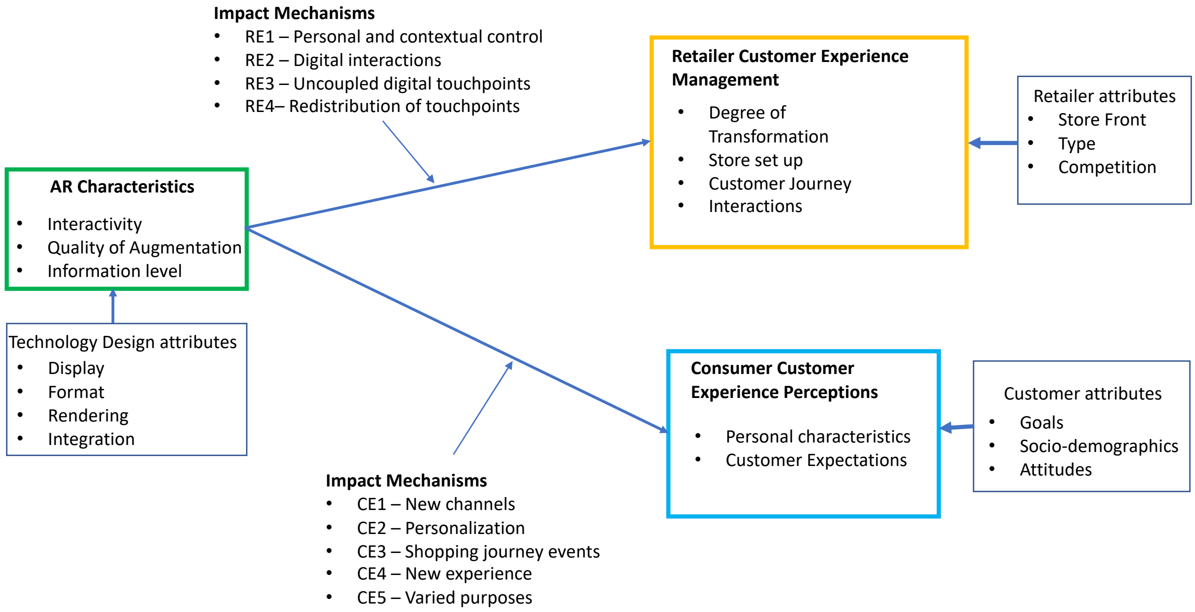

Figure 10. AR customer experience impact model

This model can be used to explain how AR impacts what retailers want to provide for customer experience and consumers' perceptions of that experience, when a solution aimed at enriching the retail customer experience is deployed in different retail settings.

5 From Impact of AR as a Technology to AR Design using Human-Centered Approaches

The two cases analyzed in the AR impact study in Chapter 4 demonstrated AR's potential to enrich the retail customer experience. These cases highlighted, however, that a technology-oriented solution tends to create doubt in customers about using the AR experience to make a purchase decision. This doubt is due to multiple reasons, as determined in the previous chapter: their goals for the shopping experience – hedonic, enjoyment or utilitarian - their social status and the demographics they belong to, their involvement and familiarity with innovative digital technologies, how sensitive they are to touch and feel, their interactions with store employees to talk about the products, privacy concerns, and their price-sensitivity and brand consciousness. The retailers engaged in customer experience management compete with other retailers in the same or different channels. They had various reasons to improve customer experience, including shifting the customer journey touchpoints using digital interactions and making these touchpoints non-linear; flexibility in how they stored products and used intermediaries; digital technologies that created a seamless customer experience.

The study showed that AR could play a critical role for both retailers and customers in enriching the retail experience in different retail settings. It made sense for customers to use AR actively to engage, experience, and make decisions (Bonetti et al., 2018). The solution should be meaningful and aligned to both the channel and the experience the retailers want to enrich. It should also make customers feel comfortable and purposeful in the way they use and experience the AR characteristics to add value in their shopping journey.

5.1 Reflections from the Impact study

To summarize, the findings from the cases in Chapter 4 demonstrate clearly that participation and involvement by users are needed to design AR solutions to enrich retail customer experience. Users include both retailers and customers with different engagement levels, needs, and wants, and should represent user and usage diversity. There are several reasons for including users in the design of AR solutions. Firstly, is there a clear need for AR as a technology to make retail experience easier or better – otherwise users will not be able to leverage the potential benefits or create an impact to why the technology was installed. Customers may engage in it for hedonic or aesthetic purposes but not make a purchase decision which might have been the intention. Secondly, does the retailer have a clear understanding of business vision of their digital and multi or omni-channel journey maturity as well as a supporting business model where AR can help drive the related business model metrics or expectations? Thirdly, it is required for users to understand which characteristics of AR are a must-have, to ensure that the highest priority needs are addressed. Given the emergence of different retail formats and expectations, involving the users in evaluating the shopping journey friction points removes much of the guesswork for retailers trying to transform the journeys by extending this technology's relevance. Finally, user involvement in the digital transformation that includes AR will hasten the introduction of useful technology into the retailer's customer experience management strategy.

5.2 Towards AR design using human-centered approaches

Emerging technologies such as AR are developing rapidly, primarily driven by focused innovation in hardware, increasing the range of devices people can use to interact with computers and applications. User interaction however becomes fragmented, and hence user expectations of a system do not match reality (Wigdor and Morrison, 2010). The development of functionality and user interfaces for these interactions rely on users' prior knowledge to exploit their expectations and familiarities (Hofmeester and Wixon, 2010). The software accompanying the new devices often lacks cohesion, standard best practices, and detailed usability design. Interfaces and interaction techniques vary, and ultimately user experience suffers (Metz, 2013). There is friction of use and engagement when the technology is implemented because of unfamiliarity, lack of usable interfaces and features, or lack of alignment to needs and interests.

Several factors influence the involvement with and experience of AR. People belong in different categories of the technology adoption lifecycle depending on how easily they can adapt and engage with new technology (Bohlen and Beal, 1957). The technology, its characteristics and need and use case influences the adoption. The influencing factors are how it compares to other technologies, compatibility and relevance, complexity or simplicity, testability and observability (peers and social networks) (Rogers, 2003; Compeau and Higgins, 1995). The assumed benefit and attitude towards use affects how users accept and use technology. Other factors include readiness of use, experience, output quality, demonstrable results, ease of use, and social acceptance (Davis, 1989; Venkatesh and Davis, 2000). According to Kaasinen (2005), perceived value of the technology, perceived ease of use, and trust are the most important factors affecting the intention of use and user acceptance of consumer-level digital technologies such as AR. The main obstacle to consumer-level applications often is getting consumers to start using the technology in the first place (Kaasinen, 2005).

If the definition of augmented reality is to be reframed from being merely technology-centric toward a human experience, AR should be defined as "a human experience with the world that is enhanced by technology". AR is a means to an end and not the end itself. It should be less about technology doing things to users and more about users engaging with the world around them and having that world enhanced by technology where and when appropriate.

Technology-driven design can mean that we augment reality with many characteristics, capabilities, and features no one needs or will not be used due to unfamiliarity or lack of understanding of how they can enrich the shopping journey experience. A user-involved design approach is essential to uncover users' latent needs and decide what augmentations to layer into the journey that will be meaningful to both retailers and customers (Olsson et al., 2011).

AR is a socio-technical ensemble (Bijker and Law, 1992), and thus its design and development should be based on human needs, and its ultimate status should accordingly be human-centered. Shin and Jung (2012) state that technical aspects have been in focus traditionally when it comes to the investigation of systems and applications and this approach is relatively narrow. The interaction between the technology, the people who use it should be highlighted along with the organizational and environmental context in which it is embedded. Sommerville and Dewsbury (2007) highlight the need for a cross-disciplinary framework representing all the aspects of technological systems. It includes the underlying technology characteristics, the market, the users, and the environment where the solution is adopted. If these aspects have not been adequately considered, the solution runs the risk of failure.

Gill (1991) defines human-centeredness as "a new technological tradition that places human need, skill, creativity, and potentiality at the center of technological systems' activities." It focuses on technology and how humans interact with it versus questioning how and why the technology may support humans. Human-centered design takes a socio-technical view (Emery and Trist, 1960), balancing the requirements of two competing "systems". Hedberg and Mumford (1975) and Heller (1989) add that the social system of interacting human activities, multiple, implicit (and often conflicting) goals, human understanding and knowledge, business context and application-specific cultures and practice, and the technical system of formal, rule-based procedures and technology, managed by performance indicators and exception-handling should be examined together.

The fundamental principles of human-centered design (Gulliksen et al., 2003) are users' active involvement and clear understanding of the user and task requirements, an appropriate allocation of function between user and system, iteration of design solutions, and multi-disciplinary design teams. Human-centered design philosophy proposes that end-users be at the center of technical system designs (Johnson, 1998, p. 32). Gould and Lewis (1985) outlined three principles that defined a "user-centered" approach: (a) early focus on the user; (b) empirical measurement, for example, usability; and (c) iteration informed by data from users. These three principles are used to define the design of a product or service.

Based on this categorization, human-centered design can be defined as the process that places human needs and limitations at a higher priority than other targets during design thinking and production differential stages. During this process, the designer must not only analyze and find a solution for existing problems but also test and validate the designed products or services against planned targets in the real world.

5.3 The human-centered design process

According to the ISO 13407 standard on Human-Centered Design (ISO, 1999), five fundamental processes should be undertaken to incorporate usability requirements into the software development process.

- **Plan the process:** This strategic activity is best performed by bringing together all the stakeholders relevant to the development to create a shared vision for how usability can support the project objectives. It links the business goals to the usability goals, ensures that all factors related to the system's use are identified before design work starts, and identifies the priorities for usability work.
- **Understand and specify the context of use:** When a system or product is developed, it will be used within a specific context and by a user population with certain characteristics and particular goals and who wish to perform specific tasks. The system will also be used within a specific range of technical, physical, and social or organizational conditions that may affect its use.
- **Specify the user and organizational requirements:** Requirements elicitation and analysis are widely accepted as the most crucial part of software development. Indeed, a software development program's success can largely depend on how well this activity is carried out.
- **Produce designs and prototypes:** Design solutions arise in many ways **-** from copying and development, by logical progression from previous designs, to innovative creativity. Whatever the source, all design ideas, as they progress, will go through iterative development. Mock-ups and simulation of the system are necessary to support this iterative design lifecycle.
- **Carry out a user-based assessment:** Designs should be evaluated throughout development, initially using low fidelity (typically paper) prototypes, followed later by more sophisticated prototypes. It is a significant activity within the system development lifecycle; it can confirm how far user and organizational objectives have been met and provide further information for refining the design.

The processes are carried out iteratively, as depicted in Figure 11, with the cycle being repeated until the particular objectives have been attained.

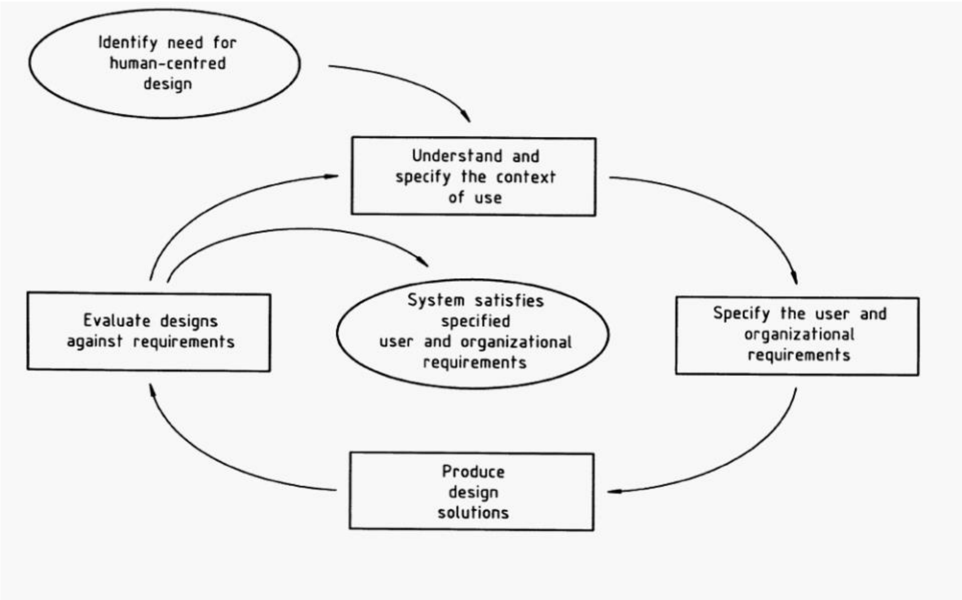

Figure 11. ISO 13407 standard for Human-Centered Design processes for interactive systems

It is becoming increasingly evident that a high level of usability via Human-Centered Design is the key to future commercial success for new technologies such as AR to be used on devices like desktops, mobile, and tablets. To ensure a successful outcome, the design team must satisfy the user's needs and wants when the development is complete. The technology and its capabilities must also substantially improve to truly enrich user experiences and thus leave a distinctly positive impression and increase commercial rewards. Future systems users must be represented throughout the process as the best option for producing usable and successful products.

The user's needs, expectations, and fears must be considered in the design process. The application has to be useful, and the user experience worth it. The solution must be developed to support the crucial aspects of its use, and the gaps and limitations in the technology adoption life cycle can be bridged. The solution will be widely adopted if users can see the benefits of using it.

Human-centered design characteristics

The findings from Chapter 4 and the Human-Centered Design process described above clarify that to ensure a successful human experience outcome, AR's technology design should meet the user's needs and wants when the development is complete, with the users validating the requirements and the design. The users must be represented throughout the process of producing usable and successful products. Following the principles and performing Human-Centered Design activities, ISO 13407 introduces a framework (Table 25) to ensure full representation of the users throughout the software design process.

Table 25. Human-Centered Design characteristics (derived from ISO-13407)

Activities	Outputs from human-centered design
Understand and specify the context of use	Context of use description
Specify the user requirements	Context of use specification User needs description User requirements specification
Produce design solutions to meet these requirements	User interaction specification User interface specification Implemented user interface
Evaluate the designs against requirements	Evaluation results Conformance test results Long-term monitoring results

This framework is used to understand the problem being solved via the understanding and specification of the use case. User requirements that relate to the specification in terms of what is needed, and how users would interact or use the specification, are critical to designing the solution. It provides what the user interface should look like and present, the testability of the designs for whether the user needs can be met, and how the solution will be monitored to learn what worked or not.

5.4 Human-centered approaches

Multiple human-centered approaches are in practical use today. These approaches are chosen based on the level of user engagement, from the early stages of providing requirements and context for the solution to being involved in the design and development of the final solution to be implemented.

User involvement: The value of user involvement in the software development process is well known. Involving users at the early stages of the process prevents costly changes later on (Damodaran 1996, Norman 1998). User involvement ensures that the software features meet the user's needs, which provides greater acceptance and better usability (Kujala, 2003; Mao, Vredenburg, Smith, and Carey, 2005). User involvement is especially useful in the early stages of development; it speeds up the development process and promotes service success (Alam and Perry, 2002; Carbonell, Rodríguez-Escudero and Pujari, 2009).

Co-design: Co-design is a participatory development process where professional designers encourage and guide end-users to develop a product, service, or organization in co-operation with them. The co-design process aims to ensure that the final result satisfies the end-user. Widely used and well-established methods to involve end-users in the design process include focus groups, scenarios, early-phase concept design, and sketching (Morgan, 1997; Carrol, 2003; Greenbaum and Kyng, 1992; Buxton, 2007). The focus group approach to co-design is a qualitative research method involving a small group of people of similar backgrounds in an interactive session led by a facilitator (Morgan, 1997). During the session, participants are asked about their attitudes and opinions about a product, service, or concept. Participants are free to express their ideas and talk with other group members. A focus group aims to determine people's perceptions, beliefs, and expectations of a product, service, or concept.

Co-creation: Co-creation is a product development approach where consumers actively cooperate with firms to create value through new forms of interaction (Prahalad and Ramaswamy, 2000). Co-creation focuses on user experience where the user can personalize how they use the product (Jaworski and Kohli, 2006). This interactive customer relationship transforms the economics of the organization and becomes part of its value chain. The terms co-design and co-creation are often used as synonyms. Co-design is used in the more general sense of involving users in the design process, and co-creation in the specific sense of co-creation sessions where users are involved in creation as future customers.

Design thinking: At its core, design thinking refers to how designers see and how they consequently think (Liu, 1996). It is an iterative and interactive process where designers can see what is there in some representation of problem-solving concepts/ideas; they draw relations between ideas to solve the problem and view what has been drawn as informing further design efforts (Do and Gross, 2001; Lloyd and Scott, 1995). The approach starts from an empathic perspective and encourages participants to view the problem and product through the end user's eyes to increase the desirability of the solution being co-designed. It is an iterative process that moves from generating insights about end-users to defining the right problems to solve, idea generation and prototyping, and finally testing through the solution's implementation.

5.5 A conceptual model incorporating Human-Centered Design characteristics

The conceptual model from Chapter 4 is extended to incorporate the Human-Centered Design characteristics (Table 25) to design AR with users. The users here are retailers and customers. They are involved in the iterative design and development of the AR solution based on a specific use case, understanding the need for AR, developing the solution iterations, and evaluating the solution's ability to enrich a particular retail experience (Figure 12).

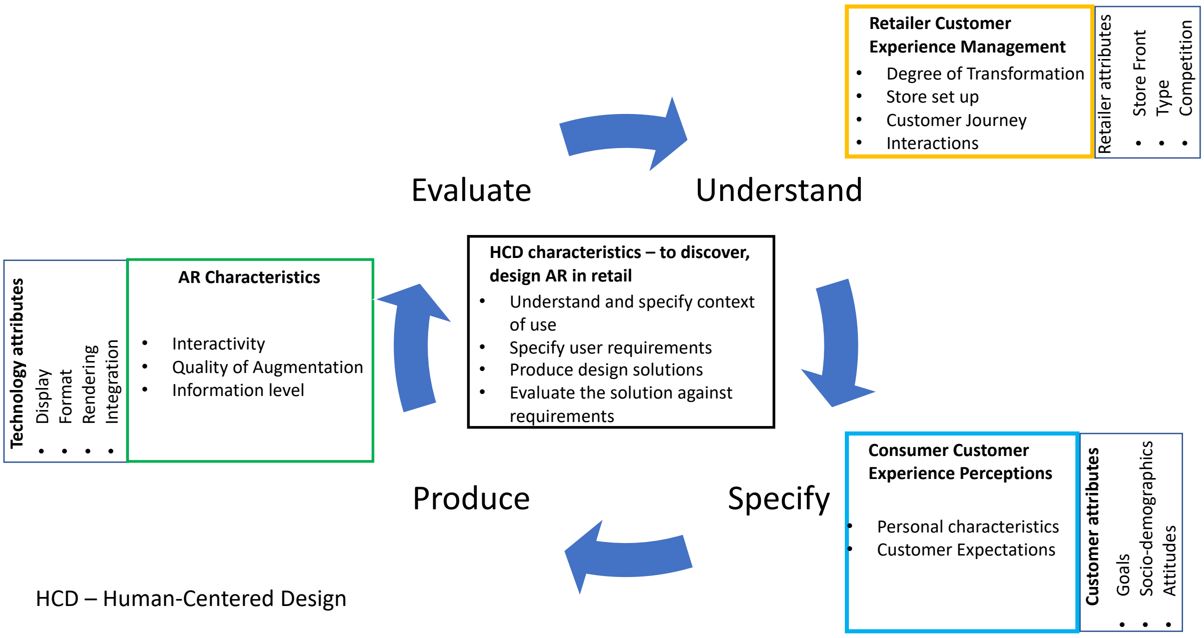

Figure 12. Designing AR using a Human-Centered approach model

In the case analyses that follow in the next chapter, the co-creation and design thinking approaches involve the users – retailers and customers - to design AR that enriches specific retail customer experiences using the conceptual model developed here.

6 AR Design using Human-Centered approaches

Chapter 4 documented the potential impact of AR on the retail customer experience. It also revealed this impact was constrained in the investigated cases by the quality of augmentation, information level related to the content, comparison and pricing of products, lack of integration with functions customers typically perform, privacy, and the fit to the customer's journey expectations. In both cases, indicative evidence pointed to the underlying reason for these set-up deficiencies being that AR was thought of as technology versus looking at it from a customer experience standpoint. Instead of taking the customer experience as the starting point, the design was characterized by technological exploration to learn about the technological possibilities and constraints relative to the retail customer experience context.

Using the conceptual model developed in Chapter 5, this chapter presents the analysis of two cases to understand how human-centered approaches could be leveraged to design AR that contributes positively to the retail experience. In contrast to technological exploration, the development processes studied were initiated in the customer experience with the AR technology framed to this end. As shown through these cases, centering the development on the customer and the customer experience makes it possible to build technically functional AR and solutions that contribute positively to enrich specific retail experiences.

6.1 Case 1: Selecting AR Based on User Involvement - ICETS

The ICETS case is presented in two parts. The first describes how technology design attributes were evaluated by involving users to select the AR technology that made the most sense to fulfill a specific experience enhancement or need. The second part illustrates how the co-creation approach is applied in this particular case.

Infosys Center for Emerging Technology Solutions (ICETS) is a group within Infosys specializing in exploring and incubating emerging technology solutions and NextGen services by identifying and building technology capabilities to accelerate innovation. The current incubation areas include AI and ML, Blockchain, Computer Vision, Conversational interfaces, AR-VR, Deep Learning, Advanced Analytics using video, speech, text, and much more. ICETS has been involved in developing immersive solutions using AR and VR for different domains, including manufacturing, sports, retail, engineering, education, and entertainment.

6.1.1 Mapping the AR design attributes to select the AR technology[16]

ICETS, with the engagement of retailers and customers, documents the key expectation areas expressed by its users to perform the task. These expectations are based on a set of extrinsic and intrinsic values, interests, and goals. The retailer expectations are experiential, training, educational, decision making, product selection, virtual settings, new operating and business models, changing mix of offering, etc. The customer perceptions of the experience could be learning, utilitarian, enjoyment, engagement, aesthetic, or fun.

ICETS works closely with the users to develop the personas, designs, prototypes, and implementation approach to understand user expectations. It applies an iterative co-creation approach to developing the AR design and technology solution. The solution is monitored and improved with continued engagement with the users, to help ICETS understand how the desired activities and feedback enhance the experience. The anticipated impacts are improved customer experience, technical quality, and the solution's feasibility and commercial viability.

ICETS starts with an accurate understanding of the experience problem where AR can add value and envisions the application. Then the users' needs are clarified. This includes gathering user requirements and also what users would like to experience. ICETS then works via a qualitative survey (Appendix 8) to map the technology design attributes that will address these requirements and develop the prototypes with the users' full engagement. Feasibility constraints and viability, mapped against the users' budgets and expected performance, are clarified. The questions ICETS asks in doing this mapping are:

- The type of positioning: Head-worn or hand-held, based on the needs of the solution.
- The role/persona and function for which the AR solution is being designed: Does the user require a hands-free operation? Should the solution be mobile or stationary? Is the solution for indoor or outdoor use? Does the design need to be interactive? Is it single or multi-user based?
- Depending on the requirements for the solution, the following specific details are focused upon: Marker-based or Markerless; brightness, contrast, and resolution of the display - fixed or adjustable; duration of use and impact on power/battery life; the cost of devices; the field of view – limited, fixed or extensible; stereoscope enabled or not; the need or not for dynamic refocus.

[16] Appendix 1 **Paper 4:** Vaidyanathan N. (2020) Augmented Reality Technologies Selection Using the Task-Technology Fit Model – A Study with ICETS. In: Rocha Á., Adeli H., Reis L., Costanzo S., Orovic I., Moreira F. (eds) Trends and Innovations in Information Systems and Technologies. WorldCIST 2020. Advances in Intelligent Systems and Computing, vol 1160. Springer, Cham. https://doi.org/10.1007/978-3-030-45691-7_61

- Is this a new design, or can an existing design be leveraged? Is this an Experiment, Proof of Concept, or for Active use? This focuses on heating, networks, battery life, hardware constraints, etc.
- Is the user subject to any geographic, social, or demographic barriers that affect the solution approach?

Post this phase, where the design attributes are mapped, ICETS uses prototyping options to understand how to enhance the user experience while also denoting the opportunities and limitations. These prototypes, where ICETS uses the available design attribute options, enable testing of solutions. It also identifies what needs to be improved or changed and whether this is reliable to meet the users' stated expectations.

The co-creation sessions with the users include continuous comments, feedback, and understanding of what the solution can provide, its shortcomings and limitations, usage, and the expected experience. They show that users and technology providers like ICETS have to continue understanding what is needed and how current technology can provide the required performance and utilization for the set-up selected.

6.1.2 Applying the co-creation approach

When customers cannot find what they want on the retailer's shelves, they can quickly shop online or with competitors. To combat this problem, a retailer was looking for a technology to ensure their shelves stay stocked or appear to have an endless aisle for products consumers are looking for. They wanted to make sure their customers found what they wanted, and that it could be shipped to the store to pick-up or their homes.

ICETS' design practice was used to design an AR solution using a co-creation approach involving the retailer, professionals, and first-time customers. The sessions were set up to understand the user expectations of a solution that would allow customers to search for products not kept in-store and ship them to their homes or back to the store. The solution needed to enable retailers to offer a much broader product assortment without worrying about shelving or storage costs.

The co-creation approach, a human-centered approach, focuses on the mechanism to create value through the interaction between the firm and its customers (Prahalad and Ramaswamy, 2004a; Payne, Storbacka and Frow, 2008), also called "value-in-use" creation (Payne, Storbacka and Frow, 2008; Grönroos, 2011). Prahalad and Ramaswamy (2004b, p.8) suggest, "co-creation is about creating an experience environment in which consumers can have an active dialogue." Consumers can co-create personalized experiences, even if the product is the same.

Different approaches are in practice to implement co-creation. In this approach, companies can gather feedback from their customers about their opinions, desires, and needs and capitalize on their problem-solving and creative skills (Füller, 2010). Companies may choose to integrate customers very early in the process from idea creation to communication, or they may choose to involve them later in the development process to keep the lead on idea generation (Vernette and Tissier-Desbordes, 2012). Choosing customers' specific attributes is crucial to enhance new product success (Grüner and Hombourg, 2000). In the idea generation phase, firms can resort to lead users, i.e., avant-garde consumers who anticipate what needs will shape and influence the market offering in the coming years and increase new product success (Von Hippel, 1986). Companies can also refer to innovator communities (Franke and Shah, 2003) or customer networks of actors. This approach favors innovation for leading companies, enabling them to be more imaginative when devising their value proposition (Cova and Salle, 2008).

Extant literature suggests that using the co-creation approach has multiple advantages. First, it shows that customer participation improves the new product development process (Fang, Palmatier, Evans, 2008) while influencing product innovativeness and speed to market (Fang, 2008). Second, for customized products, it shows that co-design experience significantly influences the perceived value of the product (Merle, Chandon, and Roux, 2008). Last, customer participation favors an enhanced perception of the firm, a willingness to recommend the firm to others, and higher purchase intent and willingness to buy (Schreier, Fuchs and Dahl, 2012).

Adapting from the popular co-creation techniques, as summarized above, ICETS engages the design professionals, retailer, professional and first-time customers in their co-creation sessions. They range from 2-3 hours each, and there are multiple such sessions to make sure what the solution will address in the specific use case, what it will not and why, so the users know what to expect when the solution is implemented. These sessions were observed, and the following steps were noted:

- Introduction with scenarios and videos: discussion of potential use cases of AR, and first impressions. In this process, ICETS does overviews of the technology, what the AR characteristics are, and demonstrates practical uses of AR with different devices and formats. This introduction allows the users (retailer and customers) to relate the detailed use cases they would like to address and picture how an AR solution makes sense.
- Experimenting with an existing AR application or solution and reflection on it: ICETS uses a current AR solution or a version of it and tests it against the use case provided. This is to get the users familiar with the use of technology for the specific use case and to spur discussion

- A discussion that includes personal opinions and preferences and general comments: In this phase, users provide their comments, options, preferences based on context and familiarity, and what they want from the solution to address the use case differently or similarly.

The co-creation sessions' learnings are used to develop the solution, with the users being engaged every step of the way.

As the consumers were unfamiliar with AR, the consumer sessions were started with an introduction to AR and what it can provide. ICETS briefly presented different scenarios illustrating an AR solution in retail used to find products. Immediately after the introduction, first impressions and opinions were collected on how realistic the participants considered the presented scenarios to be, compared to what they were looking to solve. No introduction was needed for the ICETS technology professionals, as they were already familiar with the concept of AR technology design characteristics and the types of AR they have used to date in retail.

The Head of Retailing described the specific retail experience scenario used in these co-creation sessions:

> ¨You have arrived at an apparel store to purchase a specific set of clothes. You find one you like, but there are different combinations of the clothes, only one of which is available in-store. You think you like a specific combination. The sales associate confirms that while the desired combination is not in-store, they do have it in stock, and it can be shipped directly to your home. But is the desired combination the right one? The sales associate helps you identify the specifically requested combination and other combinations in 3D on your phone. From there, you can tap into AR to place the desired combination in front of you, walk around it, and explore it up close. If you're not entirely sure, you can view a similar combination and place it next to the original one in the store via AR to see the difference in size and style. If you are still not convinced, you can try out this combination when you get home via the AR-enabled retailer's site, just like you did in the store. Not only does it match what you desire, but it is also exactly what you want. You can purchase online from there.¨

The sessions were continued by experimenting with the AR solution they were introduced to in practice. Participants were instructed in advance to bring to the sessions a few digital photos of retail settings they had seen and liked or had experienced before. ICETS then used a publicly available online retail experience image to augment the images. The application was used to activate discussion, emphasizing that the participants should not deliberate whether ideas were possible, but think creatively. The users had no prior experience using AR; however, they concretized what AR could provide with the augmented images. ICETS engineers operated the solution to prevent usability and other technical limitations from affecting users' perceptions negatively. It was done to allow users to think more of what they wanted rather than whether the functionality was technically feasible.

The users were then encouraged to make some conclusions on what they experienced. These were organized as themes: would they use this solution to find products as customers; would retailers train their sales associates on how to encourage customers to use this solution to find products that were not available in-store; what features were desired and would that lead to a purchase of something they did not physically see; were they confident of testing combinations virtually; and were they willing to share what they wanted?

The co-creation sessions provided context that professional versus first-time customers had different needs and wants. Those users who had brought pictures and images of how they imagined the ideal retail setting seemed to ideate more, wanted more features, and tested different AR options. It indicated that more engaged users who had the familiarity of possibilities came up with more use case scenarios to test out, in line with the human-centered concepts (Maguire, 2001).

ICETS operated the application throughout the session to allow participants to focus on generating ideas and the general concept rather than on the particular application and its user. The participants expressed their opinions freely, with statements such as, "I'd like to remove this piece of the aisle", "I want to see products based on my preferences¨, "Ï want the ability to check brands and prices¨, and "I'd like to add here...". If a participant came up with an idea that was not achievable with the application in question, it was discussed in detail. If the participant's idea was doable, it was executed while it was being discussed.

During the experimental part of the session, the following themes were discussed: desired functionalities, potential or actual problems, and the naturalness of the real–virtual combination.

Figure 13. Infosys web app for ¨Endless Aisles¨ using co-creation

Each co-creation session ended with a discussion of the following themes: Would you use this kind of solution when buying a new product? Would you use such a solution to buy products from an online store? What are the essential features of such a solution (when purchasing a new product or matching products or comparing products)? Would you use this kind of solution to share designs? What sorts of products could be tested virtually? Any other comments?

The co-creation sessions revealed some important takeaways regarding how retailers and customers perceived the AR solution (Figure 13) could address the retail experience of finding products not available in-store and having them delivered.

The first-time customers did not consider accuracy important; their need was whether what was presented "looked realistic". On the other hand, the professionals needed accuracy; otherwise, they would not select the products virtually. The current state of AR allows users to choose products virtually; however, these virtual objects can be moved over physical objects or overlap with other virtual objects, and this was seen as a drawback by the professionals.

Both professional and first-time customers expected a catalog where they could browse pages of combinations of clothes. Thus the "atmosphere, assortment, setting by brand, and price" was important for the experience. Customers wanted the ability to choose different colors and textures by price and search for specific brands. They also wanted the ability to "conceptualize or dream of possible combinations" using the AR solution.

6.1.3 Mapping the case to the conceptual model

The conceptual model developed in Chapter 5 is used in this case to validate whether the human-centered approach of co-creation enabled the selection, design, and development of an AR solution that enhanced specific needs for the retail customer experience and how customers perceived the experience.

Human-Centered Design characteristics affecting the selection of the AR design

In this case, the co-creation approach engaged retailers and professional and first-time customers to clearly understand the context of the use case. The retailer needs were to ensure that out of stock items or combinations not found on the shelves could still be delivered to the customers in-store or to their homes, whether the customer was in the store or browsed the product catalog from home. The multiple sessions with the customers highlighted the differences in requirements between the professionals and first-timer. The prototypes had to cater to these differences in the user interface for interactivity and information. Discussions and feedback from the retailer and customers were on whether the prototype met the user interface criteria. Was it usable, did it provide the outputs desired, and was the designed solution feasible? Could it be monitored for usability and for achieving the retailer and customer requirements to find the product combinations the customer desired while allowing the retailer to keep a manageable inventory of products on the shelves and work with suppliers for deliveries based on what the customers chose from the app, in-store or from home?

Table 26 summarizes the Human-Centered Design activities and empirical evidence from the ICETS case. The users included retailers, savvy professionals, and novice customers.

Table 26. Human-Centered Design activities with empirical evidence in the case

Activity	Outputs from Human-Centered Design	Empirical Evidence
Understand and specify the context of use	Context of use description	¨You have arrived at an apparel store to purchase a specific set of clothes. You find one you like, but there are different combinations of the clothes, only one of which is available in-store. You think you like a specific combination. The sales associate confirms that while the desired combination is not in-store is not in-store, they do have it in stock elsewhere, and it can be shipped directly to your home. But is the desired combination the right one? Fortunately, the sales associate informs you that you can see the specifically requested combination, as well as the other combinations in 3D on your phone. From there, you can tap into AR to place the desired combination in front of you to walk around it and explore it up close. Furthermore, if you're not entirely sure, you can view a similar combination and place it next to the original one in the store via AR to gauge the difference in size and style. Still not entirely convinced? No problem. When you get home, you can try out this combination via the AR-enabled retailer's site the same way you did in the store. Not only does it match what you desire, but it is also exactly what you want. You can purchase online from there.¨ (Head of Retail)
Specify the user requirements	Context of use specification User needs description User requirements specification	The co-creation session included iterations, where the customers were asked to bring retail setting images. Then ICETS overlaid 3D images on the images from a publicly available website to show the power of AR. The customers provided requirements for what they would like to experience
Produce design solutions to meet these requirements	User interaction specification User interface specification Implemented user interface	ICETS developed a web app. The users had different contexts in terms of interactions with the app. The co-creation sessions provided the context that professional versus first-time customers had different needs and wants. More engaged users who had familiarity with possibilities came up with more use case scenarios to test out, in line with the Human-Centered Design concepts. To allow participants to focus on generating ideas and on the general concept rather than on the particular application and its user, ICETS operated the application throughout the session. The participants expressed their opinions freely, with statements such as "I'd like to remove this piece of the aisle", "I want to see products based on my preferences¨, "Ï want the ability to check brands and prices", and "I'd like to add here...". If a participant came up with an idea that was not achievable with the application in question, the idea was discussed in detail. If the participant's idea was doable, the idea was executed while discussing it further.
Evaluate the designs against requirements	Evaluation results Conformance test results	Each co-creation session ended with a discussion on the following themes: Would you use this kind of solution when buying a new product? Would you use such a solution to buy products from an online store? What are the most essential

Activity	Outputs from Human-Centered Design	Empirical Evidence
	Long-term monitoring results	features of such a solution (when purchasing a new product or matching products or comparing products)? Would you use this kind of solution to share designs? What sorts of products could be tested virtually? Any other comments? The co-creation sessions revealed some important takeaways regarding how retailers and customers perceived the AR solution could address the retail experience of finding products not available in-store and having them delivered. First-time customers did not consider accuracy important; the key was whether what was presented "looked realistic". On the other hand, the professionals needed accuracy; otherwise, they would not select the products virtually. The current state of AR allows users to choose products virtually; however, these virtual objects can be moved over physical objects or overlap with other virtual objects, and this was seen as a drawback by the professionals. The customers expected a catalog where they could browse pages of combinations of clothes, and thus the "atmosphere, assortment, setting by brand and price" was important for the experience. The customers wanted to choose different colors and textures by price and search for specific brands. Customers also wanted the ability to "conceptualize or dream of possible combinations" using the AR solution.

The solution is monitored and improved as part of the continued engagement with the users to understand how the desired activities and feedback enhance the experience. The anticipated impacts are improved user experience, technical quality, the feasibility of the solution, and commercial viability.

AR characteristics and how they impacted the retail customer experience

This case revealed that the characteristics of AR (interactivity, information level, and quality of augmentation) were critical to the ability to find combinations of clothing in-store or from home. The photorealistic quality was good, and the information presented catered to professional and first-time customers, allowing them to browse products, compare choice, determine prices, and decide to have the combination shipped home or be picked up in-store. A degree of personalization was required based on the type of customer. They also had the choice to make an online payment for the option selected. Based on the co-creation approach, an AR web app made the most sense as it would be usable in different settings. The AR characteristics that were usable by the retailer and customer were limited by the technology design attributes as summed up by the ICETS head who said:

> "Before AR can truly hit critical mass among consumers and businesses, a few key challenges need to be overcome. A more sophisticated AR experience requires better hardware, better software, and more power than today's phones (and most computers) can produce. We need hardware that allows our phones and devices

to track, measure, and map the environments around us. We need software that allows devices to make sense of incoming data and map it accordingly on our screens. We need more power for our devices to process all of this data while maintaining reasonable battery life. Most importantly: We need an ecosystem of "killer apps" that demonstrate obvious and real value to customers. Enterprises, manufacturers, and consumers need to have practical reasons for buying into expensive hardware and software. When all of those elements are developed, we will have reached the "critical mass" threshold necessary for widespread AR adoption. We're not there yet, but we are so very, very close -- and our proximity to mass-market AR should garner a lot of interest from a lot of industries. "

The Head of ICETS goes on to say:

"AR will save retail. By embracing these technologies, retailers gain control of industry disruption. Virtual stores, endless aisles, virtual shopping, personalized promotions – AR will make shopping more fun, personalized, and efficient, giving traditional retailers non-traditional methods to build personal relationships and experiences, as well as offering next-day and same-day delivery."

Table 27 summarizes the characteristics of the AR web app solution co-created with the users.

Table 27. AR attributes and characteristics used in this co-creation case

AR characteristics and attributes	**Description**	**Indicative Empirical evidence**
Technology Design attributes	AR web app, multiple Image recognition and tracking of type of products, images rendered alongside physical objects, integration with online payments	¨A more sophisticated AR experience requires better hardware, better software, and more power than today's phones (and most computers) are capable of producing. We need hardware that allows our phones and devices to track, measure, and map the environments around us. We need software that allows devices to make sense of incoming data and map it accordingly on our screens. We need more power for our devices to process all of this data while maintaining reasonable battery life. Most importantly: We need an ecosystem of "killer apps" that demonstrate obvious and real value to customers. Enterprises, manufacturers, and consumers all need to have practical reasons for buying into expensive hardware and software. When all of those elements are developed, we will have reached the "critical mass" threshold necessary for widespread AR adoption. We're not there yet, but we are so very, very close -- and our proximity to mass-market AR should garner a lot of interest from a lot of industries.¨(Head of ICETS)
AR characteristics – Interactivity	Bottom-up and top-down content	Accurate sizes and dimensions are crucial for the professionals who would build the AR solution for endless aisles as the plan is used "to show how the aisles fit in the physical space". The designers emphasized the role of colors and materials in the solution and the importance of the AR mobile app solution to represent products in realistic lighting and realistic materials.
AR characteristics - Quality of augmentation	Realistic overlays of 3D objects in the physical world	As regards accuracy and rendering quality, the first-timers preferred realistic augmentation over accuracy.

AR characteristics and attributes	Description	Indicative Empirical evidence
		They considered interactions with existing products to be highly important; the solution should enable existing products to be moved and removed virtually, and virtual products to be placed where expected based on some criteria (co-creation sessions).
AR characteristics - Levels of information	Utilities (search, narration, content, need for touch), connectivity (social features), entertaining attributes (look and feel)	The professionals wanted to browse a catalog and find detailed information, including checking prices, brands, and comparing combinations. The first-timers wanted to experience a catalog with 3D objects and find combinations (co-creation sessions).

Impacts on retailer customer experience management

In this case, the retailer was looking to enhance the customer's shopping journey by using digital technology to show what was available in-stock on the shelves in-store and also other available options. Via the AR web app, customers could search and choose the combination they desired and then pay online at the store or from home and select for the product to be delivered in-store or to their homes. The customer experience management strategy was about integrating interactive technology in-store or in-home, not having to stock everything in-store, and not disappointing customers because they could not find what they wanted. The strategy also allowed sales associates to interact with the customers if desired or provided customers the ability to browse selections at their convenience and choose the combinations. The retailer could then work with the suppliers to get the combination delivered in-store or at the customer's home.

The AR web app has the potential to increase the retailer's control over the factors influencing the customer experience. Inventory management is one such parameter specifically targeted. By integrating the AR solution, the retailer enhances customers' decisions to choose the combination they desire while the products are still virtual via the product catalog. This avoids not finding combinations and thereby improves the shopping journey. More generally, the AR web app allows the retailer to take charge of some of the contextual conditions and relocate others' control to the customer via stocking brand-based specific combinations that the customer can touch and feel. They can know the price, texture, etc. and then browse the catalog in-store for different textures, colors, make comparisons, or pick another brand. When at home, they can browse the catalog, make choices, decide to purchase and pay online or come to the store to see how a comparable combination might look and feel. The employee-customer interaction (Bitner, 1992; Wilder et al., 2014) is partially replaced by an AR-customer interaction controlled by the retailer. The replacement is holistic because the AR web app is integrated with online sales channels and customer service delivery at home or in-store.

Through the AR web app, customers are given control over some contextual conditions. They can browse through the products at home, check how that might look, select a preferred brand or search for others, do price-comparisons, and choose a method for delivery and pay online after the purchase decision. They can also influence the social experience. They can show the product catalog to friends and family to get approval. However, the web app is decoupled from social media. This means that the retailer may not easily find out what customers or customer-relevant influencers have said about the experience or why they did not make purchasing decisions.

An important characteristic is enhanced customer journeys (Patrício et al., 2008; Wilder et al., 2014) with the retailer controlling the customer experience. There is a competitive advantage when the journey is not linear, and when customers do not spend time in-store looking for what they need and then being disappointed. The retailer also creates a network of suppliers to directly deliver the chosen combinations to the customer in-store or at their home (Akaka and Vargo 2015). With the AR web app, the retailer can enhance this touchpoint of the shopping journey and create a non-linear touchpoint to change the customer journey by providing options, serving up combinations to upsell to the customer. The retailer also sees the potential of extending customer journeys with more touchpoints. The AR web app encourages the customer who has seen a combination they liked in a store to virtually take the product home, browse through all the options, and compare it to other combinations. The retailer identified AR as an opportunity to improve labor costs, provide a competitive advantage, and work directly with suppliers instead of maintaining large floor spaces with high inventory.

The product catalog that has search, compare, and browse capabilities as part of the decision-making process is also identified as an opportunity for the retailer to bring the company closer to its customers. However, it is also highlighting that the retailer's customer experience expectations from this AR solution are co-created together with those customers – both professionals and first-timers. The retailer's consequences are that the customers understand what the solution provides, can be change agents for their friends and family, and the use and engagement of this solution will have a positive impact. More importantly, the AR app may also move the closure of the sale from the retailer in-store to the online option.

The retailer's negative implications are customers who may not engage with the web app and its features. They may choose to go to another retailer to find what they want, or the experience may not be good enough. They may provide negative feedback that could hurt the retailer's intentions to improve the customer experience. Table 28 shows the retail customer experience impacts using the co-created solution.

The co-creation approach included the retailer and professional and first-timer customers in developing these solutions and focused on the experience problem addressed by the web app. It gives the retailer the optimism that the customers will become change agents for what is possible and how the enhanced catalog can create a photorealistic experience to select, compare, and make purchase decisions.

Table 28. Impact of the AR characteristics on the retailer's customer experience management

Retailer's Customer Experience Management	Impact on Retailer Customer Experience Management
Degree of transformation	Via the AR web app, the retailer designed the experience to provide a personalized catalog with the content desired by professionals versus first-timer customers
Store set up	The retailer did not have to maintain all product combinations in stock and have high inventory and labor costs. Via the AR web app, customers could choose what they wanted in-store or at home, and then the retailer worked with suppliers to deliver as per customer choice
Customer journey	The shopping journey touchpoints were digitized to a large extent allowing customers to use the AR web app in-store to make choices as well as make decisions at home where they could pay online and request delivery at home or in-store
Interactions	The AR web app allowed for the redistribution of the touchpoints from the sales associate to the app. It also allowed the sales associate to interact with the customer in-store and have them use the app when they could not find what they wanted in-store

Impact on customer perceived experience

Customers who go to physical stores to shop for specific products may struggle to find what they want, know whether it is available, try it on, and form negative impressions based on interactions with the retailer or previous experiences. The problem statement in this case talks to the customers' perception of what the retail experience offers. This perception is furthered by their reason to come to the store, the store's demographics and location, and their interaction and engagement with the retailer's digital technologies or brands and prices offered.

The customer experience is based on the consumer's perception of customer experiences (Kranzbühler et al., 2018). When customers start to use the web app, they can receive input from other virtual shoppers on social media. This possibility refers to the uncontrollable influence that other customers can have through their reviews and social media posts. The digital world brings dramatically more opportunities for these interactions and effects. One customer's poor experience that traditionally would stay in the store can now, after being documented online, reach millions of potential consumers in a blink. The retailer's prospective customers recognized this possibility, declaring that the AR web app would increase the impressions from other customers. The retailer recognized that retailers also catalyze consumers to influence each other in this way.

The personal characteristics (Holbrook and Hirschman, 1982) that link to the perception of the web app-mediated customer experience include the customer's engagement and digital savviness and what they expect. Professionals determine the experience based on the AR web app's quality to visualize the product at home and reduce the risk involved in the purchase decision. Because it allows for a more personalized consumption process, the AR web app gives the opportunity to target customers differently according to what they provide as information – comparing choices, brand differentiation, delivery methods, and making the purchase decision at home or in-store.

The consumer perspective's expectations focus on key events in the customer journey and how they impact the experience (Ross and Simonson, 1991; Verhoef et al., 2009). The AR web app introduces new events that may stand out as extreme events. First, visualizing the products and options at home can determine the whole experience. The co-creation discussion provided the context of the professionals' expectations versus the first-timers for how they would experience photorealism. Statements such as "I want to see products based on my preferences", "Ï want the ability to check brands and prices", and "I'd like to add here..." were made by the customers. The customers, both professional and first-time, expected a catalog where they could browse pages of combinations of clothes. Thus the "atmosphere, assortment, setting by brand, and price" was important for the experience. The customers wanted the ability to choose different colors and textures by price and search for specific brands. They also wanted the ability to "conceptualize or dream of possible combinations" using the AR solution.

Conversely, the AR web app also can create events that stand out as negative experiences (Sivakumar et al., 2014; Tax et al., 1998). One issue expressed was uncertainty whether the product aisles for selection were correctly represented in the AR web app. The first-time customers did not consider accuracy important; their need was whether what was presented "looked realistic". On the other hand, the professionals needed accuracy; otherwise, they would not select the products virtually. The current state of AR allows users to choose products virtually; however, these virtual objects can be moved over physical objects or overlap with other virtual objects, and this was seen as a drawback or bottleneck by the professionals.

Another way the AR web app transforms the events of the customer experience is by moving the interaction with the product spatially from the retailer's premises to the consumer's home and giving the customer a choice to browse the options in-store. The staff would counter negative experiences at the store by providing the AR option to browse what the customers wanted and offer other options. When using the app, the retailer is not aware of negative experiences that may happen. Because there are limited channels to connect to the retailer when using the app, consumers said they might walk away from the product, choose another online experience, or go to another retailer.

The case applies the conceptual model from Chapter 5 to demonstrate the impact of the AR characteristics on the retailer and customer experience. Table 29 below shows this impact, based on the app developed during the co-creation sessions, where the retailer and participating customers' inputs and needs were considered.

Table 29. Impacts of the AR characteristics on customer perceptions

Perceived customer experience	Impact on Consumer Perceived Customer Experience
Personal characteristics	It offered both professional and first-time customers using AR and interactive technologies a new way to interact with the retailer to find the product combinations they desired The personalization varied between the types of customers regarding the level of detail desired, the interaction quality, and expectations for search, comparison, brands, pricing, etc.
Customer expectations	The AR web app offered different shopping events based on whether the customer went in-store or used it from home to browse the product catalog for fun or whether they made decisions to buy Critical for customers was browsing the catalog at their convenience and not forming negative impressions because what they wanted was not in stock in the store

Given the nature of this case, the impact of the AR characteristics of the finally implemented AR web app was not studied. However, the co-creation sessions provided for mapping the impact of the conceptual model's characteristics against consumer perceptions of customer experience.

6.2 Case 2: Applying Design Thinking to Enrich Apparel Try-Out Experience - Infosys

This case with Infosys uses the design thinking approach for an AR solution for a luxury retailer to enrich the apparel try-outs experience. The apparel industry receives a lot of user-experience related feedback on the cumbersome experience of apparel try-outs. On the other hand, retailers are keen to recreate their brick and mortar establishments into unique experience zones leveraging technology, thus inviting shoppers to brand new experiences. Intending to attract customers to indulge in futuristic digital and omnichannel experiences, Ralph Lauren (RL), a leading luxury brand with a global presence, was keen on listening to its customers while designing empathetic solutions.

Two companies were involved in this case.

- Infosys Limited is an Indian multinational corporation employing over 250,000 employees. It platforms emerging technology solutions, provides business consulting, information technology, and outsourcing services. The company is headquartered in Bangalore, Karnataka, India. They have a significant presence in India, the United States, China, Australia, Japan, the Middle East, and Europe.

- Ralph Lauren Corporation is an American fashion company headquartered in NY, producing products ranging from the mid-range to the luxury segments. They are known for clothing, marketing, and distribution of products in four categories: apparel, home, accessories, and fragrances.

6.2.1 Infosys Design Thinking approach

The Design Thinking approach is a human-centered approach used to discover unmet needs and opportunities and convert them to create value through customer experience (Brown, 2010; Lockwood, 2009). The approach is based on applying designers' methods to solve problems, especially management issues, through a process based on the following steps: inspiration, ideation, and implementation (Brown, 2010). Understanding users' needs is crucial in this innovation process, especially in the early stages, to identify what users really need. Therefore, many designers develop "empathy" towards consumers through in-depth visual observations and ethnographic research techniques (Leonard and Rayport, 1997). It is a way to positively affect idea generation and product superiority (Veryzer and Borja de Mozota, 2005). Designers are more likely to identify new solutions that will lead to new product offers (Brown, 2010) by representing these ideas using different tools such as sketches or prototypes. These tools help make communication more efficient, enabling teams to focus on a tangible production-ready solution (Utterback & al., 2006; Brown, 2010).

Thinking like a designer can transform the way organizations develop products, services, processes, and strategies. This approach, which is known as design thinking, brings together what is desirable from a human perspective with what is technologically feasible and economically viable. It also allows people who are not trained designers to use creative tools to address a vast range of challenges (IDEO Design Thinking approach).

The Design Thinking (DT) approach (Figure 14) used for the case with Infosys is adapted from the IDEO Design thinking process, which focuses attention on the user to arrive at the right solution for the problem. The process starts from an empathic perspective and encourages participants to view the situation and product through the end-users' eyes to increase the desirability of the AR solution being co-designed. It is an iterative process that moves from generating insights about end-users to defining the right problems to solve, idea generation and prototyping, and finally testing.

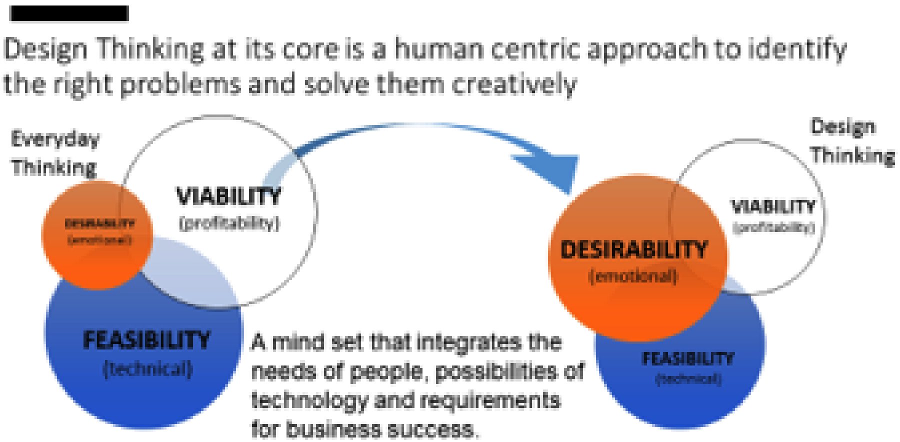

Figure 14. Infosys Design Thinking approach

One of the most critical aspects of the AR solution is understanding how the selected technology and its characteristics provide the desired retail customer experience and whether that is viable for the retailer and customer. The user experience is more than usability, perception, or customer adoption patterns; it deals with the emotional interaction with the AR technology and the physical and virtual environments in which it operates.

The data organized from the interviews and focus groups are used to visualize the required experience from using an AR solution. The solutions created in the visualization phase are enhanced by considering the role technology can play to solve the problems at scale. It is like envisioning the application even if it appears to be beyond the current development tools' capacity. The visualizations are then crafted into early experiments. Users can experience the early versions of the visualizations to confirm if they align with expectations or need further modifications.

The process goes through five constructs, each a phase that works with stakeholders, leveraging templates and conversations.

Empathy: is to look at the needs of the users, not only to gather user requirements but also uncovering what users would like to experience. Creating an empathy map is an outcome of this phase; it helps with a clear view of each stage of the experience where impact can be made, and related problems faced. The user problems surfaced at this phase might be inaccurate visibility of images or the display or inadequate response from retailers during the user journey. Ease of use and fulfilling needs are parts of user experience. The psychological aspect of the users towards the AR-based experiences could be captured in this phase. This phase's outcomes would vary according to relevant customers' persona – ranging from the millennial, digitally savvy buyer to the digital adopter. For this corporate professional, the application of digital to their physical experiences enhances their convenience and comfort. These experiences are drawn out as customer journey maps.

Define: is the process by which the designer arrives at a meaningful and actionable problem statement and is likely the most challenging part of the design. It requires the designer to synthesize observations, insights about users, and the user's stated and unstated needs, based on the empathy phase. This phase leverages templates to define problems specific to each persona to alleviate the pain from the problem spaces and multiply the gains and positive experiences.

Ideation: This is perhaps the most critical milestone in enhancing the user experience. It deals with facing the users' challenges and generating various innovative solutions to the findings of the empathy phase. Ideas come with experience or by sharing. They also come from borrowing from similar situations faced by other industries unrelated to the current context. Solutions could range from higher image resolution to larger displays, from quicker response to problems encountered in different stages of the empathy map to the ease of use of current experiences, hence fulfilling critical user experience needs.

The focus is on generating many ideas in the first phase of ideation while not considering too closely or pondering the ideas' quality, feasibility, or viability. The idea is to encourage sharing and cross-pollination of perspectives to find unique ways to solve the problem. The second phase of ideation encourages learners to consider the feasibility and viability of ideas generated. It also is the crucial phase that brings in the lens of solving the problem at scale. It requires consideration of the opportunities and limitations provided during the prototyping phase.

The key is to combine ideas that have been generated in meaningful ways to bring about desirable, feasible, and viable solutions at scale.

Prototyping: involves the implementation and testing of solutions in an agile manner. It is the phase that allows the designer to take the idea that it is in their head and bring it to reality in the simplest possible way. Prototypes can range from paper prototypes to storyboarding to screen prototypes. It allows the user to experience the solution as envisaged by the designer.

Test: This is the phase where users test the solution prototype in their real-life settings. Ideally, the user experiences this without guidance. Testing is crucial to producing an application that is reliable and answers to user expectations. The element of surprise or extra excitement is a plus, a differentiator in user experience.

AR blends reality with a computer-generated layer to make user experiences more meaningful through engaging interactions. Questions typically asked within the DT approach relate to three overlapping constraints: **desirability, feasibility, and viability**. It's helpful to measure the effort needed to execute a solution with the potential payoff in terms of desired outcomes, whether monetary or some other quantifiable measure. If the investment far outweighs the benefits, it may be worth focusing on a different solution.

The Design Thinking process enables the co-design and development of an AR solution in line with user participation and feedback. The retailer and customer understand the expected customer experience and what the solution provides, with its shortcomings and limitations, including commercialization and costs for implementation and usage.

The Infosys Design Thinking approach was used in this case over four months to engage RL and customers upfront in the understanding of what AR technologies offer, what benefits they get by using the technology, and how it can enrich retail experience and usage.

Applying the Design Thinking approach to select an AR solution

The empathy phase was centered on enhancing customer convenience in-store, personalizing the experience, and offering choice. RL wanted to enhance the retail experience by providing product information and options to customers without them looking for clothing physically and trying them out, reducing the returns of clothes due to misfit, and dealing with negative customer feedback that impacts the experience. RL wanted to have an opportunity for customers to reach out to a sales associate if they needed to, have the ability to transact in a language of their choice to create a sense of personalization, as well as offer other products as up-sell options to the customers to go with their product selections.

Empathy Conversations: Interviews and focus groups were conducted with users (the retailer and other stakeholders) across segments in-store and online, and these were the insights gained:

- Personalizing meant that customers were keen on a variety of options and on an experience that elevated their sense of self and ownership during the buying experience.
- Because RL is a luxury brand, an observation was around a shifting customer base with more current generation customers spending time with luxury brands. These time-starved customers were seeking the best available shopping experiences that met their needs of any time anywhere.
- One of the most common mentions was the inconvenience of leaving the dressing room to find an alternate size or color after selecting the apparel design.

Define: Defining the focus areas was a journey in itself. With available technology, there is more significant potential to work on customers' desirability goals. Technology solutions could range from leveraging cameras and sensors to projection and reflection. Following the discussions, the focus chosen was to enhance the fitting room retail experience for the customer.

The users that impacted this experience ranged from the fitting room personnel to the store operations manager who needed to plan and manage staffing to suit fitting room usage. An additional stakeholder was the merchandising team: the fitting room retail experience for the customer and data that emerged from this would help merchandisers understand if their apparel had crossed the soft hurdle of trials as they moved from the shelf to the fitting room.

Ideate: The team worked out wild and wacky ideas leveraging thoughts from cross-industry ideas and implementations of AR and AI (Artificial Intelligence) to enhance the retail experience. They included the convenience of getting input without trying outfits, cameras scanning body shape and suggesting sizes for best fit, colors that would best suit the customer, and notifications to sales staff to bring appropriate alternatives as per the customer's choice without them having to step out of the fitting room. There were also explorations on upselling, which from the customer's eyes would be alternative accessories and apparel that would go well with the one they have chosen, or the mirror sharing notifications with them and interacting with them live. Other ideas included selecting the language they wanted to interact in, choosing to delay making decisions via sending the information of filtered choices to their email, and offering other products that go with selected products, creating upselling opportunities for RL.

While this exploration was possible by leveraging technology, it was also important not to create a new problem while solving an existing one. An example that was discussed in this case was that cameras could significantly enhance convenience for customers. However, this could be seen and experienced as an invasion of privacy and needed to be considered with care. One of the outputs from this session was using customer journey maps to identify the themes to create the prototypes.

The customer shopping journey maps were created using Post-It notes posted on a white wall. The team would walk around to theme them and remove parts of the journey that either created friction in the flow or was considered a nice-to-have versus a must-have capability. The journey used for prototyping from the ideation sessions is visualized below in Figure 15.

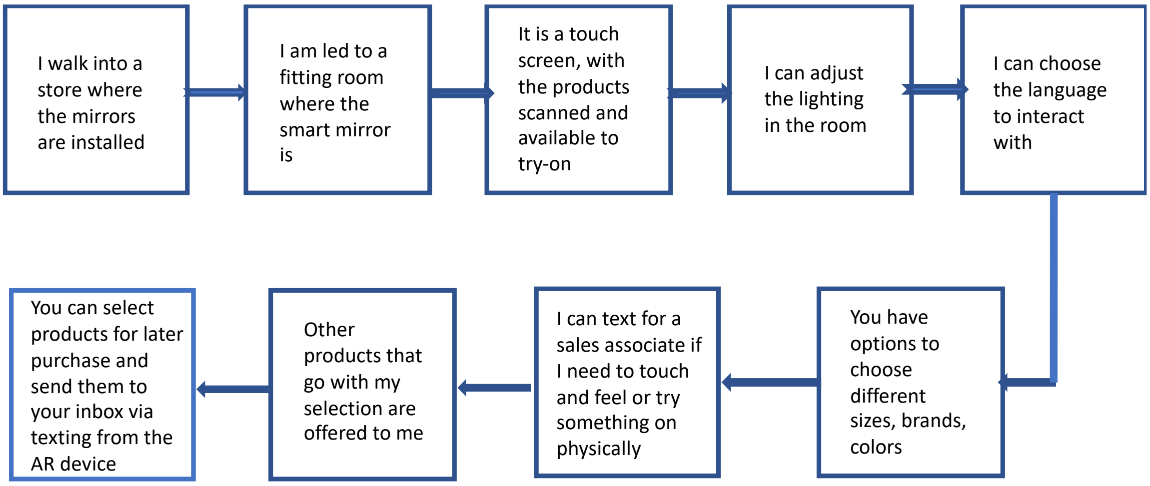

Figure 15. Journey map used for prototyping

Prototypes and testing were done, keeping feasibility and viability in mind. RFID technology was leveraged to manage the privacy concern that had emerged. The RFID scanners protected the customer's privacy, but created friction and disturbed the seamlessness of the experience. Mirrors were interactive screens that shared apparel color options and allowed the customer to choose sizes or other preferred alternatives. The screen and related computers also worked to serve notifications via text messages to the fitting room staff, enabling the customer to not step out of the fitting room. The customer could change the fitting room lighting, request a different size, browse through other items in the store, or interact with a sale associate through the mirror (Figure 16 interactive mirror). Appendix 12 illustrates the resulting customer journey post installing the smart mirrors in RL


Figure 16. The RL experience post installing the interactive mirrors

6.2.2 Mapping the case to the Conceptual Model

The conceptual model developed in Chapter 5 is used in this case to validate whether the human-centered approach of design thinking enhanced the specific needs for RL's customer experience related to virtual fitting and how customers perceived the experience.

Human-Centered Design characteristics affecting the selection of the AR design

This study used the Design Thinking approach where users engaged in understanding the problem context, provided requirements around the customer experience related to apparel try-outs, defined what they expected as part of the experience, and visualized the possibilities. The solution included integrating with AI for personalization and RFID to protect the customer's privacy. It included the retailer's perspectives on convenience, upselling, and customer service while the customer was in the fitting room. The feasibility and viability of the solutions were prototyped and tested. Table 30 summarizes the Human-Centered Design activities and empirical evidence from the study.

Table 30. Mapping the Human-Centered Design characteristics to the Design Thinking approach used in this case

Activity	Outputs from Human-Centered Design	Empirical Evidence
Understand and specify the context of use	Context of use description	Ralph Lauren (RL) was seeking to enrich the apparel try-out experience for its customers, which was the basis of the study – (the problem use case from the retailer)
Specify the user requirements	Context of use specification User needs description User requirements specification	RL wanted to enhance the retail experience by providing product information and choices to customers without them looking for clothing physically and trying them out, reducing the returns of clothes due to misfit, and dealing with negative customer feedback that impacts the experience. (retailer provided use case)
Produce design solutions to meet these requirements	User interaction specification User interface specification Implemented user interface	The users that impacted this experience ranged from the fitting room personnel to the store operations manager who needed to plan and manage staffing to suit fitting room usage. An additional stakeholder that we discovered was the merchandising team. The fitting room retail experience for the customer and data that emerged from this would also help merchandisers understand if their apparel had crossed the soft hurdle of trials as they moved from the shelf to the fitting room. (retailer use case, design thinking sessions) The retailer wanted to use for upselling and convenience while the customers wanted privacy and personalization as well as physical interaction with the store employee when needed (design thinking sessions)
Evaluate the designs against requirements	Evaluation results Conformance test results Long-term monitoring results	Mirrors were interactive screens that now shared apparel options in colors and allowed the customer to choose sizes or other alternatives they preferred. The screen and related computers also worked to serve notifications to the fitting room staff enabling customer convenience to not step out of the fitting room. You can now change the lighting in the fitting room, request a different size, browse through other items in the store, or interact with a sales associate through the mirror (design thinking prototypes, solution)

The solution is monitored and improved as part of the continued engagement with the users to understand how the desired activities and feedback are used to improve the experience continually. The anticipated impacts are improved user experience, technical quality, the feasibility of the solution, and commercial viability.

AR characteristics and how they impacted the retail customer experience

Based on the user engagement upfront that catered to user expectations and requirements, the AR smart mirror was selected as the device, and a markerless format was used to display the virtual objects in the fitting room. Here, the customer could get the right level of information and interact with the choice of lighting needed, preserve privacy, get personalized selections, and get external assistance via a sales associate when required. The integration of the mirror with AI and RFID was influential in the solution set-up for the in-store luxury retailer. Table 31 maps the AR characteristics to the empirical evidence from the case.

Table 31. Integrated smart mirror design attributes and characteristics mapped to empirical evidence

AR attributes and characteristics	Description	Indicative empirical evidence
Technology design attributes	Integrated smart mirrors designed for iPhones, markerless, integrated with texting, AI, and RFID technologies	A markerless set-up integrates the smart mirrors with iPhones with text capability, AI for personalized choices to try-out, and RFID to protect privacy. Integrated to AI and RFID for personalization and privacy
AR characteristics - Information level	Bottom-up and top-down content	¨It's a touch screen — similar to an iPad or tablet — and includes all the necessary features shoppers might need while trying on clothes. When I enter the fitting room, all of the items I wanted to try on were already scanned and entered onto the interactive mirror.¨ (design thinking sessions – customer comments during CJ walkthrough) ¨Next, you can choose the language you wish to use. ¨ (design thinking sessions – customer comments during CJ walkthrough)
AR characteristics - Quality of augmentation	Realistic overlays of 3D objects in the physical world	¨Before trying on the items, you can set the lighting of the fitting room to your liking. I'm not a fan of fluorescent lights, so I want the darkest setting.¨ (design thinking sessions – customer comments during CJ walkthrough) ¨If the color or size of your item isn't working for you, you can choose something different from the options on the mirror... ¨ (design thinking sessions - – customer comments during CJ walkthrough)
AR characteristics - Interactivity	Utilities (search, narration, content, need for touch), connectivity (social features), entertaining attributes (look and feel)	¨After I picked out some clothes to try on, an employee led me to the fitting room where I was excited to find the interactive mirror.¨ (design thinking sessions – customer comments during CJ walkthrough) ¨Next, you can choose the language you wish to use.¨ ¨The mirror will also double as a personal shopper by recommending other items that might go with what you're trying on. This is a smart way to get shoppers to spend more money.¨ (design thinking sessions – customer comments during CJ walkthrough)

AR attributes and characteristics	Description	Indicative empirical evidence
		¨When you find something you like but aren't sure if you want to buy it that day, you have the option to send the information about that item to your cell phone. The mirror will text you.¨(design thinking sessions – customer comments during CJ walkthrough)

Impacts on retailer's customer experience management

The Design Thinking approach, via the interaction of Infosys with the retailers and customers who participated, led to the selection of an AR integrated smart mirror as the solution to handle the customer's virtual-fitting concerns, increase brand awareness, and improve store return policies.

Concerning the contextual conditions (Mathwick et al., 2001; Surprenant and Solomon, 1987), RL provides an integrated AR smart mirror to try-out apparel in the fitting room to contact a physical sales associate if needed. The smart mirror provides personalization and privacy via AI and RFID integration to the smart mirror.

The integrated AR smart mirror can increase RL's options for upselling and convenience for the customers. Simultaneously, customers can try out different apparel, choose the lighting they need, reach out to the sales associate, and consider other offers presented comparing apparel and providing choices. The sale process is important for the retailer RL: it should ensure the experience is good, provide options, and reduce the need to return because of try-out fatigue.

More generally, it allows RL to take charge of some contextual conditions and relocate the control of others to the customer. The employee-customer interaction (Bitner, 1992; Wilder et al., 2014) is partially replaced by an AR-customer interaction and a sales-associate-customer interaction if needed using texting. RL controls what is offered in-store versus what is available virtually for customers to select via the integrated smart mirror.

The smart mirror's capability to personalize and provide the means to select and make a decision further enhances the customer and RL touchpoints. It allows RL to give options and comparisons and enables the customer to reach out if necessary if specific fittings or choices are not found on the integrated AR smart mirror. Table 32 summarizes the AR characteristics' impacts on the retailer's customer experience management.

Table 32. Impacts of AR characteristics on retailer's customer experience management

Retailer's customer experience management	Impact on retailer's customer experience management
Degree of transformation	Customers have a sense of making the try-out choices in the language of their choice with adjusted lighting and the ability to seek help when needed
Store set-up	The integrated smart mirror with AI (personalization) and RFID (privacy), as well as the ability to text (physical engagement as needed), provided the customer the choice to try out products digitally or as a combination of physical and digital or physically if they did not find what they wanted using the smart mirror
Interactions	Customers have the choice of pre-scanned apparel in combinations that make sense for them. They can choose the language in which they want to interact, select the clothing they want, make purchases on their app, as well as reach out, if needed, to the store associate for clarifications, other choices, or physical clothes without having to walk around the store

Through the smart mirror, customers have control over some contextual conditions. They can check how the different combinations of clothes fit, the price, and the brand before physically checking them out in the store. They can also influence the social experience by telling their friends and family that you don't have to go throughout the different aisles to check out the clothes and their prices and whether they will fit. The customer also can directly interact in a language of their choice and reach out to an employee if needed to get the right apparel. However, because the smart mirror is detached from the online store, RL is not seizing an opportunity to engineer the social experience, for example, by providing customers using online or mobile channels the experience provided in-store by providing an omnichannel experience.

With the smart mirror, RL has ambitions to extend beyond the improvement of an isolated touchpoint and create different touchpoints to enhance the customer journey. The aim is to move the first interaction with RL to earlier in the customer decision-making process. RL also sees the potential of extending customer journeys with more touchpoints. The integrated smart mirror encourages the customer who has tried out different combinations of apparel and how they fit, to decide whether the attire is right for them and make a purchase. It also offers RL options to upsell in the fitting room and customize the interactions via language preferences and physical interaction with a sales associate.

The integrated AR smart mirror uses RFID technology to protect the identity of the customer. The use of AI personalizes the combination of apparel, brand, price, and comparable choices for customers to try-out. These are already scanned when the customer arrives in the fitting room.

Reaching customers at an earlier stage of the decision-making process is also identified as an opportunity for RL to bring the company closer to its customers. This is by providing them the entire selection of the offered products, and being available to interact with them to use the integrated smart mirrors, validate their choices, and offer them a way to deliver what they decide to purchase. By engaging with customers this way, RL has the potential to reduce the returns of products bought. However, this is also putting light on the fact that RL and the customer experience are co-created together with this integrated smart mirror. The consequence for RL is that they are a luxury retailer with high-end products, and customers more clearly come into the store to touch and feel the product, and believe in engaging directly with the RL store employees. Decision-making is based on the relationships of these interactions. It could create negative implications for the retailer for pointing the customer to integrated AR smart mirrors upfront in the fitting room. However, that negative implication is neutralized by the capability to text store employees to ask for physical products as needed.

Impact on customer perceived experience

The case demonstrated many positives in the integrated smart mirror, including the integration to make the experience private and personalized while providing options to choose a language, the desired lighting in the fitting room, and connecting with store employees as needed.

AR can enhance enjoyment values (Huang and Liu, 2014) by adding virtual information to real information and offering 3D pictures of products in different shapes, colors, and styles. Virtual objects and the information contributed by AR may heighten the users' enjoyment and mental imagery (Schlosser, 2003). AR, as system output interacting with the real world, creates the experiences of captivation and intuitiveness to enjoyment, inspiration, and creativity (Olsson et al., 2011). This solution allowed users to enjoy the immersive environment, choosing a language they wanted and the level of lighting they required in the fitting room, without having to walk around the store looking for products, pricing and fitting the apparel.

Table 33 summarizes the impacts of AR characteristics on consumer perceptions of customer experiences. The factors influencing the consumer's perceptions include other consumers being present at the time of the experience (Chen et al., 2009; Kim and Lee, 2012). Given RL is a luxury retailer with high-end clothing, the integrated AR smart mirror provided a digital or a ¨phigital¨ retail experience where the customer could reach out to the store employee as needed for questions, clarifications, or specific apparel. This physical interaction gave customers the comfort of not making a decision based only on a digital representation of the apparel.

The Head of Retail at Infosys says:

> ¨Investments were done in stores, with the needed iPhone screens for the store staff. RL found that customers were valuing the experience that allowed them convenience in myriad ways. Discovering improvements in the rapid prototyping phases brought us to issues like the initial investment in screens and the compatibility being

restricted to iOS. Apart from large retail luxury stores, it didn't seem viable to invest heavily in smaller stores as the number of staff allocated to the fitting rooms led to another issue of limited labor available to service the enhanced customer experience. The industry challenge of the high cost associated with building AR experiences seemed to be a stumbling step in the execution at scale.¨

Table 33. Impacts of AR characteristics on consumer perceptions of customer experience

Customer experience	Consumer perception of customer experience
Personal characteristics	Provides opportunities for the retailer to offer digital products in physical stores while also offering employee interactions. The smart mirror experience being an app can easily be shared with other customers in terms of what it provides and choices they had, even though they make decisions in-store The integrated smart mirror with AI (personalization) and RFID (privacy) and the ability to text (physical engagement as needed) provided the customer the ability to try out products digitally or as a combination of physical and digital or just physically
Customer expectations	The sequence of actions in the customer shopping journey can be in any order where they can make a choice, decide to check out, change their mind, call for an associate, then try again digitally, choose to use the physical aisles if wanted The customer could be concerned about the degree of personalization where items are already pre-scanned, and combinations and choices are provided. There could also be a perception that the retailer knows a lot about the customer. This could raise concerns about security and privacy Conventional touchpoints might have waiting periods due to the need to get assistance, find the aisle where the product is, seek help for different colors, sizes, etc., and then go through the whole hassle of try-outs and returns. With integrated smart mirrors, this is all possible digitally across the customer shopping journey

Aesthetics can be controlled through design, color, virtual reality, and vividness (Mathwick et al., 2001). The entertainment value comes from consumers' enjoyment of the shopping experience (Babin et al., 1994). Both the visual appeal and entertainment of the aesthetical experience delivered by the smart mirror offer an environment that facilitates the smooth accomplishment of consumers' specific shopping tasks. It is the most important factor for the consumer to maintain and invest in a relationship with the retailer that employs AR. The smart mirror transforms the events of the customer experience by moving the interaction with the products virtually in-store on the retailer's premises while the products are physically in the aisles. The integrated smart mirror introduces new events that may stand out as extreme events and reshape the retail environment, making it more immersive and efficient.

This new AR experience from Infosys has enhanced the customer retail experience in many ways across different touchpoints. It will let shoppers view digital representations of products before committing to a purchase, and learn more about what they are buying. They can see additional options not available in the physical location and get instant recommendations or other information relevant to their unique experience. First, visualizing the products and try-on for fit and comfort creates an initial enhanced retail customer experience. The customer does not have to search for the products by going around the store, waiting for store employees to ask questions about a product, nor stand in line to make payments or carry products home. A luxury brand like RL with this trendy integrated AR smart mirror allows customers to explore possibilities and options to self-serve in-store. They can do this the same way as they would do on mobile or online and check the physical products and engage with store employees as needed. AR has brought about the possibility of virtual objects in a physical store.

The same users do not frequent the set-up in a high-end stores for day-to-day product selection and purchasing. This affected active use of the technology at the outset. However, the integrated smart mirror provided for personalization and privacy, which are typically the concerns of high-end shoppers.

Conversely, the integrated smart mirror also can create events that stand out as negative experiences (Sivakumar et al., 2014; Tax et al., 1998). Given the high-end products at this luxury retailer, customer expectations may not be met by being asked to use the smart mirror. They may walk away without interacting with the in-store employees or checking the physical products, and perceive the interaction as negative. There could also be a sense of ¨being watched¨ where RL knows everything about the customer beforehand.

The case applies the conceptual model from Chapter 5 to demonstrate the impact of the AR characteristics on the retail customer experience, after using design thinking to build the app for RL, a luxury in-store retailer. The study did not include post-implementation results. Infosys provided a customer's shopping journey walkthrough (Appendix 12).

6.3 Contrasting the cases

Involving target users in the design and development process using co-creation and design thinking approaches in the two cases helped with understanding the big picture of the problem statement, customer expectations, and the retailer's customer experience outcomes. It also shows how targeted use cases could be used to design AR and develop solutions based on the underlying design attributes and the characteristics provided for the specific retail experience.

The cases used two different human-centered approaches. The ICETS case used the co-creation approach to engage the different users. They also had two types of customers who provided requirements and validated the design. The Infosys case used the design thinking approach iteratively to test and validate the prototype for feasibility and viability to meet the underlying expectations. In each case, the human-centered design characteristics were validated with empirical evidence. This analysis showed that the human-centered design principles, which include engaging with users, ensure that user needs are met, and if not, the users know what is feasible upfront. They are made aware of the technical limitations of the AR solution being developed and what to expect that is viable for enriching retail experience in the use case context.

The two cases engage users upfront in designing the AR to enrich the retail customer experience. They address specific problems or outcomes and attempt to close the gap that emerged from having a pre-defined AR solution, focused on AR as a technology, to understand how it impacted the retail experience. Once these solutions were installed in each case, the experience-related concerns that still existed were primarily due to the technology's limitations. The conceptual model developed in Chapter 5 was validated using the AR design study.

Users' needs were understood. The technical characteristics and limitations were known to the users upfront (Bohlen and Beal, 1957). Their engagement and feedback helped select the set-up that could enhance the underlying retail experience challenge. Using co-creation techniques, the first case helped users understand the technology design attributes of AR solutions and how they could fulfill the particular need or outcome that the retailer wanted to enhance for the customer. The case demonstrated that human-centered approaches are critical if users are to understand what the AR solution provides. In the second case, there was a sense of ownership because the users provided feedback at every iteration of the prototyping and testing to ensure that the co-designed solution addressed the underlying problem. This involved added technologies – in this case, RFID for privacy and AI integrated into the mirror for data gathering for personalization and for a physical exchange with a store employee via texting.

The second case was built on top of the first case. It went further than just mapping user needs to the technology provided, and the co-creation sessions applied to a specific case. It explained why AR was the best solution for addressing negative feedback related to looking for apparel, fitting them, returns, etc. The case extended the first case because it made users part of the multidisciplinary focus groups, across iterations, and ensured that the feasibility and viability of the solution were valid. It involved user emotions, participation, feedback, ownership, and a higher probability that the co-designed solution would indeed enhance the retail experience it was set to resolve (Rogers, 2003; Compeau and Higgins, 1995).

Overall, both cases are critical in evolving immersive technologies in retail and taking it to a more scalable and effective solution for enriching the retail customer experience. They provide customers options to be in different retail formats – in-store, online or mobile - using AR to accept, adopt, engage, experience, and make decisions (Davis, 1989; Venkatesh and Davis, 2000). As Retailers continue to transform their offerings in the different formats, they can use customers upfront to design the experience needs and make the shopping journey more convenient across touchpoints. They can integrate the various digital technologies to enhance the journey using AR and have options for physical conversations and interactions as needed across these touchpoints (Frost and Sullivan, 2012).

Furthermore, these cases show that with adequate human-centered approaches, one can determine the users' mindset and needs and design solutions that support those needs through AR solutions. These cases showed no unique "best (AR) technology" that could be applied across the board; instead, the particular characteristics of each problem set should always be considered, along with the user experience and the use environment as a whole. In both cases, another important aspect is that users are individuals with individual preferences. The cases revealed that for AR solutions to impact the retailer's customer experience management and the consumer's perceptions of customer experience, user needs, expectations, and fears must be taken into account in the design process.

The cases demonstrate the need to connect AR technology to how retailers use it and how customers expect to experience its characteristics. The users' needs, the use environment, and the business ecosystem all play a role in this success, and therefore each must be considered in all stages of the development of AR experiences.

6.4 Proposed Steps to Design Effective AR Experiences

From the impact case studies and the design case studies, it is clear that customers are of different types and their expectations and goals differ for why they may engage with and use innovative technologies like AR. It is also clear that the technology has multiple software and hardware limitations to be overcome (Chapter 3 and the studies).

In this chapter, the co-creation and design thinking approaches demonstrated that when the retailer and the customers were involved upfront, they are more aware of the characteristics and limitations of AR, and more explicit about what it can and cannot solve, from a retail customer experience standpoint. For retailers, these approaches provide a clear understanding of the use case of customer experience management they intend to solve and how customers perceive what the design can offer. For customers, the approaches provide a good avenue to specify what they require from a solution and determine whether those requirements can be met or not, and therefore how it can impact their retail customer experience and journey. AR is, by nature, an impressive visualization method, and over the years, many AR implementations have been based on a wow-effect. However, these cases show that this effect is not enough for typical users; the design of the solution should be helpful in a meaningful way to the user. While co-design is an established research method in other areas, it has been less applied to designing AR solutions.

Based on the cases analyzed, mapping the empirical observations from each case to human-centered design considerations for AR, the following steps (from Chapter 2) are proposed for the design of AR to develop solutions (Siltanen, 2012) to enhance retail customer experience elements:

Identification for the need for AR: A key discovery from the cases was that consumers who explored new technologies and got involved early were not only interested in exploring more ideas, but also came up with more ideas, compared to those who used AR less frequently or were first-timers (ICETS co-creation case). This means that the clarity and understanding of the concept, using the user's familiarity and engagement with AR, motivates the user, and results in more well-laid out use scenarios. This finding is in line with the general concepts of human-centered approaches (Maguire, 2001) and user innovations (von Hippel, 1986, 2005). User expectations regarding AR are generally similar to those for any other emerging or new technology; there must be a need to use this technology, and the technology should be easy to use, solves a problem or makes something better or easier. In the case of the ICETS case, AR enables the user to test different combinations and browse a catalog of options to make decisions independently. Users are prepared to invest effort if the expected benefit from using the technology is high.

Business model being addressed or created: Once the user expectations are determined, often there are many ideas and options (ICETS co-creation case). The number of desired features may be vast, expectations may be contradictory, and different user groups may have contrasting opinions (ICETS case). In this situation, one must select the best or most important features for further development (ICETS and Infosys cases). A viable business model is essential for a successful AR solution (in both cases, the use case was laid out for why AR might be the best option). It must also fit with the retailer's business problems (related to the need to stock all products, as in ICETS, or enable users to virtually try-out and experience a personalized and secure experience, in the Infosys case). Thus, one selection criterion is to choose a viable business model as a basis for further development (Bagdare, 2016). Another way to limit the work is to focus on the most prospective target users and user groups (ICETS and Infosys cases). In this study, selected features were chosen to address the underlying business use case. A natural continuation would be to implement the rest of the identified features in the future. While adequate functionalities are essential for the user, a viable business model is needed for the existence of AR in the first place.

Identification of user requirements: The cases validated that users can produce useful ideas regardless of their knowledge of the underlying technology. Depending on their level of involvement with innovative technologies, they also have different expectations, needs, and opinions regarding functionality and preferred ways of using the solution (ICETS case) (Mosiello, Kiselev and Loutf, 2013).

Thus, a one-size-fits-all approach to AR design might fail. User involvement in the design phase helps to take into account the expectations of the specific target group (ICETS and Infosys cases).

The study verified that human-centered approaches are well suited to discovering user expectations regarding AR design. Also, involving several different types of users (ICETS case) in the early stages of concept design proved valuable for two reasons: it gave a good general view of the subject and revealed differences between users. The latter is especially important if the target users belong to several user groups. Involving different actors and user groups enables working out a feasible solution. A viable solution is essential for the existence of an AR solution in the first place. In the literature, co-design has been seen as useful to the design process and both users and retailers (Steen, Manschot, and Koning, 2011). The outcomes in both cases are in line with these findings in creating more effective AR experiences. Human-centered approaches revealed many user expectations to be fulfilled to achieve the intended customer experience.

Identification of must-have characteristics of the solution: The customer experience is improved if the user can interact with the solution in the way that they want. As pointed out in the ICETS case, for first-time users the interaction should be effortless. For professional users, the aim of use is more subtle, and the technical requirements are higher. Professionals can use the solution only if certain existing drawbacks are resolved, such as the level of information presented and the quality of the augmentation (to see how the combination of clothes matches what is available physically, in the ICETS case). The number of requirements that the users propose during co-creation might be extensive, and there might be a need to reduce the number of features to be implemented. One possible means of limiting features is to categorize the elements according to physical function and user-satisfaction.

Kano (2001) and Kano, Seraku, Takahashi, and Tsuji (1984) propose the following categorization: attractive quality elements, provides user satisfaction if functional although the user can tolerate a lack of these elements; one-dimensional quality elements, which can provide user satisfaction if functional, and cause dissatisfaction if dysfunctional; must-be quality elements, whose function is always required and which cause dissatisfaction if dysfunctional (this was a limitation seen from the AR impact study cases in chapter 4).

Must-be quality elements are bottlenecks of the solution. Without them, the solution is not feasible. One-dimensional quality elements have a significant impact on user experience and are thus important; hence, the technical solution must be reliable. Attractive quality elements can improve user experience but are not vital to the solution – they are not the first features to develop and implement. The must-have features versus the next to have or nice-to-have features must be categorized upfront in the human-centered approaches, so the solution designed accounts for the must-have features first (ICETS and Infosys cases).

Selection of a feasible subset of features: For the customer, a good experience consists of easy and pleasant use of the application and satisfying results. For the retailer, good experience means that the solution is easy to deploy and supports the business model and retailing strategy (Väänänen-Vainio-Mattila, Oksman, and Vainio, 2007). In other words, the solution needs to be valuable to the customer, in addition to being useful, usable, and desirable (Morville, 2004). The two cases identified expectations for the solution to enrich the retailer experience. Fulfilling these expectations is what is primarily needed to improve the experience. Solving critical challenges and bottlenecks makes the solution valuable and usable for the user. Enabling other desired features makes the solution desirable and pleasant to work with. In other words, during the development process, one must consider the must-have characteristics of the solution to address the use case (ICETS and Infosys use cases).

Development of a technical solution: The AR solution was developed for ordinary users, taking the user requirements into account, paying close attention to the customer experience, and addressing the specified use cases from the retailers in each case. Though AR continues to mature, it still has many limitations that can affect the user experience (Chapter 3). Users need flexibility in terms of how the AR characteristics are presented – vividness, quality of augmentation, and level of information presented - to optimally experience the impacts of AR in their shopping journey in different retail settings. Using human-centered approaches (Maguire, 2001) means that these limitations can be clarified to the users so they know what can or cannot be satisfied with the design of the solution and understand its feasibility to address the specific retail experience challenge (ICETS and Infosys cases).

Evaluation and testing the solution: This is an important step, demonstrated in both cases. The participants evaluated the iterations of the prototypes produced to make sure their requirements were being met, what they provided versus not, and whether the solution was feasible and viable to meet the needs of the problem use case presented by the retailer. By testing the solution in each iteration, the users knew the drawbacks of what was being proposed and were, therefore, more mindful of how it would work when implemented. For the retailers, testing ensured the solution did not add friction in the customer touchpoints. For customers, it provided context for whether the solution, when implemented, would create negative impressions or take them away from their intended shopping journey. A framework to design AR solutions with users is depicted in the table below (Table 34).

Table 34. Steps to design AR solutions with users

Steps to design AR solutions with users	Impact of performing the step
Identification of the need for AR	Can the AR solution address the problem entirely or make something better or easier?
Business model being addressed or created	Is the use case clear for the underlying business model? Or does it create a new business model for the retailer – online versus in-store or both?
Identification of user requirements	Are there different types of users? What do each type of user require? A one-size-fits-all design will not work
Identification of must-have characteristics of the solution	Does it satisfy the physical function, and does it address the one-dimensional and must-have quality elements identified?
Selection of a feasible subset of features	Do the features selected address the business problem, and do the customers find it useful, usable, and desirable?
Development of a technical solution	Are the users aware of the limitations? Does the solution still address the problem and make it easier or better?
Evaluation and testing the solution	Do the users understand the drawbacks? Can the solution be tested? Will it create negative impressions and friction when implemented?

In his paper, Gregor (2006) describes the Type V theory as Theory for Design and Action. This theory says ¨how to¨ do something. The framework presented above (Table 34) articulates specific steps and the impact of each of these steps on how to design AR solutions with users. The steps relate to the Type V theory by providing a rationale for why the technology is needed, a clear understanding of the problem use case, and how it affects the business model being impacted. It includes what the users need, whether the chosen technology addresses the problem and what the users have termed as must-have requirements, and whether the solution creates ease of use, usefulness, and desire. Finally, it evaluates and tests the solution designed to ensure that the desired quality is achieved while knowing the technology limitations.

7 Discussion

While AR continues to make inroads in the retail domain, this thesis sets out to position AR technology relative to an ongoing transformation of retail towards competing on differentiated customer experiences (Bagdare, 2016). To do this, the thesis has focused on two areas. First, to explain the potential impact of AR on the retailer's customer experience management strategy and the consumer's perception of the customer experience (Bonetti et al., 2017; Hwangbo et al., 2017; Javornik, 2016). Second, by using human-centered approaches (Maguire, 2001) to design AR experiences with users to develop solutions to enrich specific retail customer experience use cases.

To set the foundation for the analyses presented in this thesis, literature reviews covering AR technology and its use in retail, customer experience, and how AR plays a role in retail customer experience were integrated into an initial theoretical framework. This framework served as the basis for the AR impact study, in which two cases were analyzed to propose an explanatory model. The model highlighted nine impact mechanisms (Chapter 4) by which AR impacts retailers' customer experience management and consumers' perception of customer experience. A conceptual model incorporating human-centered design characteristics was developed (Chapter 5) to transition from a technology-centric approach to evaluate how AR was experienced as an interactive technology by customers and retailers, and where they encountered friction with engagement and usage. This model was used to analyze two additional cases that focused on the design process. These cases engaged users upfront to design AR solutions to address specific use cases in the retail customer experience and used two human-centered approaches - co-creation and design thinking (Chapter 6).

The AR impact study (Chapter 4) provided insights into how AR enriches the retail customer experience in-store and in a mobile setting. The retailer could use this solution to transform the underlying interactions to digital interactions, providing for non-linear touchpoints in the customer journey; integrating with other digital technologies to enhance the shopping journey by connecting touchpoints digitally; providing a personalized offering, using AR to make customers feel that they were in control, where they could use the set-up to experience the opportunities, search and compare products and offers; and choose to make purchase decisions using the interactive AR solution.

Based on the human-centered approaches used in the analysis of the cases, Chapter 6 developed a framework for how to design AR solutions and the impact of each step on the design of the solution. These steps are very similar to general software development processes (Benyon, 2010; Maglio, Kieliszewski, and Spohrer, 2010), but emphasizes the need to cater to the rapidly developing technological capacities of this emergent technology. These steps underscore the connection between technology and emotional response in the context of subjective perception of customer experience. AR is an impressive visualization method, and over the years, many AR demonstrations have been based on a wow-effect. However, the findings reported in this thesis show that this is not enough for customers; the solution should be an enabler in a meaningful way for them to experience something of value from the retail shopping journey touchpoints.

7.1 Answering the research questions

The findings from the AR impact and AR design process cases analyzed are synthesized to answer the research questions that were posed in Chapter 1 at the outset of this thesis.

RQ1: How does AR enrich the retail customer experience?

AR is still a relatively new technology, with few brands deploying it, and can be seen as highly novel (Javornik 2016). While consumers might want to try AR for its novelty, it is not known whether the novelty factor alone drives trial and usage, at least in the short term. Accordingly, there might be an initially large positive increase in willingness to use AR; however, the magnitude of change in usage resulting from novelty might reduce to baseline levels relatively quickly after an initial roll-out (Ferraro et al., 2017) if the AR solution does not provide value for how retailers use it or customers engage with it to enrich the retail customer experience. In sum, while AR is an emerging and exciting technology, there are gaps in extant knowledge regarding AR's positive or negative effects on the customer experience. This research attempts to close the gap.

The explanatory model from Chapter 4 visualizes the impact of the AR characteristics of interactivity, quality of augmentation, and levels of information on both the retailers' customer experience management and the consumers' perception of the customer experience. The model emphasizes the critical role of the characteristics of AR, and how they affect the retailer and customer attributes via nine impact mechanisms, in different retail settings and formats, based on the digital transformation journey of the retailer, the goals and expectations of the consumer, and affected by choice of the right AR technology. The AR impact study demonstrated that AR has the potential to be an effective technology to enhance the retail customer experience in different formats – in-store, online, and mobile.

The characteristics of AR can be drawn on to engage with customers in new ways to create an enhanced customer experience. It can be used in the various touchpoints of the shopping journey to enhance the knowledge of the products offered, and virtually try-out or experience how a product can fit in the chosen environment. It also enables customers to make purchase decisions if they find the desired product with the desired colors, features, size, price, and brand. Both the Saks and LP cases demonstrate that by using AR, retailers can digitize interactions and make the shopping journey for the customer non-linear. Retailers have different opportunities to transform themselves: optimize store policies, remove intermediaries, offer assortments by brand and price combinations, offer comparisons, upsell due to personalization, and compensate for the offline versus online settings of retail, providing a realistic offering in these channels.

AR, via its impact mechanisms, has the potential to create new channels of experience for the customer, as, for example, a virtual experience in-store in the Saks case, where the customers could browse and choose products of different sizes, colors, brands, and combinations. By interacting with a product, customers feel more confident about their choice (Kang et al., 2020; Suh and Lee, 2005). Regarding offline shopping (Saks case), one of the major concerns is effort, where having to try on clothes physically is not always a pleasurable experience for consumers (Barnes et al., 2016). AR, using integrated smart glasses (Saks case), can alleviate these issues and provide a better, more playful experience (Kang et al., 2020) as well as enjoyment derived from the use of the technology (Goetz et al., 2006). Consequently, the Saks case demonstrated that AR smart glasses as a tool for virtual try-on in retail could offer features such as informativeness and playfulness, which can improve the customer experience (Kang et al., 2020).

The degree of personalization is another impact mechanism. The Saks case showed that customers like to feel special. AR can help consumers feel special in several ways during their shopping experience. One advantage of AR is that it aligns with the growing consumer demand for personalization (Pallant et al., 2020). An increasing number of brands offer consumers the ability to choose different features for their product design (Saks and LP case). However, as previously noted, the consumer's ability to visualize the final product during the design process varies and may deter consumers from engaging in customizing products (Kim and Lee, 2020; Pallant et al., 2020). By integrating AR with value added services, it can provide secure personalized information and interactivity that makes the customer feel more confident that their privacy is not compromised.

The AR impact study showed that AR can enhance consumers' perceived psychological ownership before making a purchase (Pierce et al., 2003). AR may be one way to enhance co-creation and personalization value (Varadarajan et al., 2010), thereby increasing consumers' feelings of psychological ownership (Jussila et al., 2015; Pantano and Servidio, 2012). This was demonstrated in the Saks and LP study where the customers, using the AR experience, felt in control of what products they looked at, tried, and whether the solution made sense for them.

Another AR impact mechanism is its potential to provide new experiences for the customers. Both the Saks and LP cases showed the negative impact of this mechanism in that customers might find it necessary to touch an item before purchasing it (Liu et al., 2017). With the prominence of online shopping (LP case), many consumers engage in research shopping - searching for items on one channel and then purchasing them on another (Verhoef et al., 2007). A shopper might search online and then go to a physical store to see how the product looks (LP case). Consumers may find it difficult to visualize an item online and want to see it in person, demonstrating a strong need for touch. AR could diminish consumers' need for touch, reducing the amount of research shopping and channel switching (LP case). Research has shown that the more direct the path to purchase, the more likely it is that a consumer will complete a transaction (Willems et al., 2017). This is the positive impact of AR on the new experience provided by in-store and online channels.

While retailers are digitizing interactions, the AR impact mechanisms for control and personalization, and re-distribution of touchpoints can have a negative impact on customers. For example, the use of AR as a way to browse products and virtually experience them would add an extra step to a consumer's shopping experience (Saks and LP case). Some shoppers might consider this additional step as requiring too much effort and see it as a lack of interaction with the sales associate (Saks case). The LP case found that AR can save consumers time and effort and improve their decision-making ability (Hilken et al., 2017). Customers find it essential to know what is happening and feel that they control the technology (Saks and LP case). One key issue is adequate feedback from the technology and verification of completed transactions (LP case). The feedback should reach the customer. It is important that fonts, colors, animations, etc., catch the user's attention and help them focus on essential things. In other words, the AR solution should helpfully guide the customer's attention. The technology could also utilize audio feedback and other modalities. The customer's personal characteristics and expectations driven by their goals, socio-demographics, and attitudes will determine how they perceive this experience.

AR allows for new shopping events via its impact mechanism. However, they can be impacted by how the AR solution is set up and whether it is standalone or integrated with other technologies, applications, or services. AR provides 3D product information, including different colors and styles, enhancing users' perception of reality (Saks and LP case). AR also provides the user with enriched product information gained from physical and online stores (Saks and LP case). For example, in the LP case, AR allows the user to simulate the product's features in mobile shopping (Fiore et al., 2005). Besides, AR empowers users to share their personalized experiences on social networks, enhancing playfulness, as demonstrated by the LP case (Huang and Hsu-Liu, 2014).

AR can enrich customer experience in retail in many ways, as illustrated by the AR impact case studies, but it is not without limitations and opportunities to mature. Here it is important to note that customers need to be familiar with this interactive technology to use it. They need to be confident in the choices and decisions they make and understand what the technology offers in the retail environment. Retailers need to be mature in their digital journey and have clarity on their business model regarding where this technology plays a part in the pre-purchase, purchase, or post-purchase steps in the customer's shopping journey. Areas that emerged from the studies show there is more to do in this technology if it is to be an enabler of the retail customer experience.

The limitations of the technology design attributes of the AR display used in the retail setting can impact the extent to which the retail customer experience is effective. Various factors can limit the personalization or degree of control provided by AR: is it standalone or integrated; is the information presented by AR relevant for the consumer; does it create a disconnected customer journey that produces friction; does the re-distribution of control of the touchpoints in the journey create dissonance and negative impressions? Retailers have to understand these AR impact mechanisms on their business model, customer experience management strategies, and digital transformation journey as a differentiator to enhance the customer experience. The Saks and LP cases showed the potential for AR impacts to provide both retailers options to offer products in different channels, eliminate intermediaries, create a competitive advantage, and provide consumers options and choices for the products they offered. The Saks case also demonstrated that the integration of authentication, a digital wallet, and a choice in delivery method opened up the digitization potential of the entire shopping journey - pre-purchase, purchase, and post-purchase.

Must-be quality elements are bottlenecks of the technology; without them, the technology is not feasible for active use. For example, in the Saks case, the must-be quality elements related to the content provided, size and weight, heating, quality of the 3D objects, friction-based integration, privacy concerns, rationale for use. While adequate functionalities are essential for the user, a viable business model is needed for the retailer's existence in the first place (both Saks and LP are luxury retailers, and it was hard for customers to skip the human interactions with the in-store staff). The impact mechanisms can affect whether the technology design attributes positively or negatively influence the experience of the retailer and the consumer.

AR should be seen as a system feature, a part of a more extensive system with many other features, for many consumer-level applications. Bernardos and Casar (2011) analyzed business models using multiple mobile AR applications. They noted that, in many cases, the AR feature is added to the existing application only to enhance the customer experience. For the most part, based on extant literature and external perspectives, AR technology is in a mature enough state to support workable technical solutions. Thus, the challenge is to fulfill expectations to ensure good customer experience and develop technical features that promote the goals of engagement, experience, and technology usage. Accordingly, to solve the research problem and enhance AR towards mass-market use at the consumer level, there is a need to consider user involvement in designing and developing these solutions.

From an impact perspective, the findings indicate that the results are generalizable for different types of AR applications in retail and how the retail experience can be enriched. However, as explained in Chapter 5, there is a need to shift from seeing AR as just another technology to it being a human-centered experience, which, despite its limitations, could address specific retail experience challenges or improve experiences, and has users involved in its design.

RQ2: How to design AR to enrich specific retail customer experiences?

A natural first stream of development initiatives in retail has approached AR technology with an explorative technology interest, focused on learning about the rapidly developing technology capacities (Dünser, Grasset, et al. 2007). RQ1 validated how the impact of the AR characteristics enriches retail customer experiences, yet retailer and customer engagement goes a long way to use the right solution for the intended situation. This is due to multiple reasons including customers' goals for their shopping experience, their social status and the demographics they belong to, their involvement and familiarity with innovative digital technologies, how sensitive they are to touch and feel, lack of interactions with the store employees to talk about the products, privacy and security concerns even though the augmented products were personalized, price-sensitivity, and brand consciousness. Retailers engaged in customer experience management compete with other retailers in the same or different channels. They have various reasons to improve customer experience: they want to shift the customer journey touchpoints using digital interactions and making these touchpoints non-linear, provide flexibility in the way they store products and how they used intermediaries, improve store policies, and use digital technologies to create a seamless customer experience. The AR impact study demonstrated a clear need for retailers and customers to understand why AR is needed, what it provides, and how it can enrich specific retail experience elements.

Users have traditionally been involved in testing visual perception issues, task performance and in the development of interaction techniques and user collaboration (Swan and Gabbard, 2005; Shen, Ong, and Nee, 2010). They have however been sparsely involved in the design phase of AR solutions, and although co-design is an established method in other fields, it has been rarely used in designing AR solutions. AR is a means to an end and not the end itself. It should be less about technology doing things to users and more about users engaging with the world around them and having that world enhanced by technology where and when appropriate. That means that instead of technology-driven design, it is essential to use a design approach with user involvement to uncover the users' latent needs and decide what augmentations to layer into the journey that will be meaningful to both retailers and customers (Olsson et al., 2011). AR is a socio-technical ensemble (Bijker and Law, 1992), and thus its design and development should be based on human needs, and its ultimate status should accordingly be human-centered. Gill (1991) says that the focus on technology and how humans interact with it should be flipped to questioning how and why technology may support humans. Chapter 5 provides a rationale for why there needs to be a shift from seeing how AR is viewed merely as a technology to why AR design should be human-centered.

Human-centered approaches can reveal user expectations of emerging technologies such as AR. The study used two different approaches to design AR solutions that made sense for what the retailer wanted to achieve in respect of the underlying problem scenarios related to customer experience. It addressed customer's expectations of what was possible and then developed the AR solution that met these objectives, knowing upfront what was feasible and its limitations. The framework at the end of Chapter 6 documents the steps for how to design AR solutions with users, based on the analysis of the two cases for AR design using human-centered approaches.

Today, AR solutions in retail have been primarily used as experiments to understand how retailers and customers interact and draw value from it, and the limitations and implications. The ICETS co-creation sessions highlighted the variation between the new versus experienced users, with different needs and opinions regarding functionality and the preferred ways of using the AR technology. Variation was predominantly based on familiarity with innovative digital technologies, reflected via the different expectations and preferences for AR (Mosiello, Kiselev, and Loutf, 2013). Thus, a one-size-fits-all approach to AR design might fail. User involvement in the design phase helps to take account of the expectations of the specific target users.

The research verifies that human-centered approaches are well suited to discovering user expectations regarding AR solutions (ICETS and Infosys cases). Besides, involving several different types of users in the early stages of concept design proved valuable for two reasons: it gave a good general view of the subject and revealed differences between users. Involving different actors and user groups in ideating solution approaches with ICETS and Infosys helped the users understand whether AR was indeed the right solution. In the extant literature, co-creation has been seen as useful to the solution design process, and both users and service providers (Steen, Manschot, and Koning, 2011). The outcomes from the AR design cases are in line with these findings.

After determining user expectations, ICETS and Infosys ended up with many options. The number of desired features may be many and diverse, expectations may be contradictory and conflicting, and different users may have contrasting opinions. In this situation, the most essential features must be selected for further development (co-creation and design thinking approaches used in the studies). A viable underlying problem use case is necessary for a successful AR design. One selection criterion is to choose the possible business use case as the basis for further development. Another way to limit the work is to focus on the most prospective users. The ICETS and Infosys cases had specific use cases that needed to be addressed to enrich the retail customer experience, including finding product combinations the user wanted and providing a personalized and secure experience.

Though the number of requirements that the users propose during co-creation may be large, the number of features to be implemented must be reduced. The features should be categorized according to physical function and user-satisfaction, aligned with developing the desired AR solution. Using the proposed categorization from Kano (2001) and Kano, Seraku, Takahashi, and Tsuji (1984), the ICETS case uses the criteria (Chapter 3) to help select the design attributes for the AR solution needed.

For the customer, a good customer experience includes the easy and pleasant use of the AR set up that yields satisfying results. For the retailer, good customer experience (CX) means that the solution is easy to deploy, supports the business CX management initiative, and addresses the specific retail experience (Väänänen-Vainio-Mattila, Oksman, and Vainio, 2007). In other words, the AR solution needs to be valuable to the user, in addition to being useful, usable, and desirable (Morville, 2004). The ICETS and Infosys cases underscore these customer experience imperatives in the human-centered approaches used.

From these cases, users' engagement (including different types of customers) in the AR solutions design and development creates more stickiness for why the solution is needed, as what the technology provides versus what it does not is understood upfront. Both these AR design cases show that these human-centered approaches to develop AR solutions can enrich retail customer experiences.

Solving critical challenges and bottlenecks makes the solution valuable and usable for the user. Enabling other desired features makes the solution desirable and pleasant to experience. In other words, one must consider the unique characteristics of the retailer's desired functionality that is being enriched during the development process (ICETS – endless aisles with a catalog to browse; personalized, secure virtual fitting for Infosys)

AR is an area where photorealistic rendering is appreciated; realistic lighting and shadows are therefore essential. Dimensional accuracy is also crucial when deciding whether a lamp fits in an existing space (finding from LP case that needs a design focus). Secondly, the lamp is seldom in an empty space. The space is occupied with existing furniture, and occlusions and collisions between real and virtual objects create friction (finding from LP case that needs a design focus). Solving these issues improves the user experience considerably in the use of similar AR applications.

The purpose of using AR is to enable users in a meaningful way. This means it is critical to understand the AR technology's underlying design attributes and select the technology that makes sense for the specific customer experience improvement or the characteristics it is meant to address. The Infosys and ICETS cases determined how to select, design, and develop AR solutions that are feasible and viable to enhance specific elements of retail experience. A well-designed AR should be practical, easy to use, easy to learn, organized, symmetric, attractive, and pleasant if it is to provide useful and relevant information to users. It should contemplate the emotional aspects of the experience. AR should be novel and enjoyable to empower and encourage users to express themselves on social media. Chapter 6 presents a framework, based on the analysis of the cases, for how to design AR with user involvement to enrich specific retail experience elements or scenarios.

Human-centered approaches may not create ideal AR designs that everyone will accept and engage with when installed. They are based on a representative number of participants, their ideas and explanation of the problem use case and its interpretation, the designers' skillsets, and limitations of what the technology offers. The larger population has many different biases, goals and expectations, and perceptions of a good customer experience. However, it is a starting point for more research on how human cognition and beliefs and values can be used to design solutions with emerging technologies like AR.

7.2 Theoretical Contributions

The extant literature reviews in Chapter 3 uncovered gaps that this research attempts to close. The identified elements of AR are technology, context, and customer experience. One of the gaps uncovered was that little is known about the contexts where AR is used to enrich the retail customer experience. Instead, there has been much progress in technological aspects among practitioners and the research literature. Using two cases to demonstrate the impact of AR in retailing, this research attempts to uncover AR's potential to enrich the retail customer experience.

Second, there was a gap in extant literature that combines in-depth case studies of AR applications with cross-case analyses to compare different types of retailers and situations. This leads to understanding the conditions under which AR is more or less suited to the context, and the extent of the potential value of AR in practice to enrich customer experience. This research uses both in-store and mobile contexts in two different retail settings - clothing and lamps - to understand how AR can impact customer experience at the organizational and customer levels.

Third and finally, there was no study or article in extant research on how to design AR experiences by engaging customers and retailers upfront to develop solutions to achieve intended outcomes. This engagement becomes important to define the specific needs for which the AR solution is required and how it will enhance a particular retail customer experience gap or challenge. This research uses the human-centered approaches of co-creation and design thinking, in two different cases, and engages with retailers and customers to design AR experiences to address specific customer experiences.

Based on the analysis of the cases and its findings in both the impact of AR study and the design of AR study, the important theoretical contributions from the research are the explanatory *AR customer experience impact model* presented in Chapter 4 and the *Designing AR using human-centered approaches model* presented in Chapter 5. The research also provides a *framework for the steps to design AR expriences with users* as presented in Chapter 6 based on the analysis of the two cases studied.

7.2.1 AR customer experience impact model

The AR customer experience impact model integrates two research streams. The first is research on AR and the emergent sub-stream of AR in the context of retail (Boneti et al., 2018). The second is a stream of research on digital technology impacts in retail experience (Demirkan and Spohrer, 2014; Pantano, 2014; Hagberg et al., 2016; Pantano, Rese, and Baier, 2017; Pantano, Priporas, Sorace, and Iazzolino, 2017). The model offers an integrated customer experience theoretical framework and an explanatory conceptual model for how AR can impact retail customer experience.

This model can be used to evaluate if retail customer experience strategies are "good enough" and improve them accordingly. The model determines the extent to which retail experience can be enhanced through the nine AR impact mechanisms, as developed in Chapter 4, on both the retailers' customer experience management strategies and consumers' perceptions of customer experience. Simultaneously, the conceptual model emphasizes the critical role of how the characteristics of AR, via the nine impact mechanisms, impact the retailer and customer attributes in different retail settings and formats. These attributes are further impacted by the retailer's digital transformation journey and the consumer's goals and expectations, played by choice of the right AR technology, able to respond to actual "call to action". The model is simple to describe in terms of what AR technology characteristics are and how they are affected by the underlying technology design attributes. Yet it is distinctive (Gregor, 2006) in how the dimensions of AR, Retailer, and the Consumer can each be explained with respect to individual attributes in each dimension. The impact mechanisms can affect the dimensions for how AR can enrich the customer experience in retail.

Combining the advice by Gregor (2006) and Guba and Lincoln (1994), the five evaluation criteria against which the explanatory model of AR impact on retail customer experience should be assessed are: Novelty, Credibility, Transferability, Dependability, and Confirmability. Table 35 evaluates the criteria set out in Chapter 2 to assess the explanatory model from Chapter 4, a key contribution from this research to the extant theoretical knowledge.

Table 35. Evaluating the contribution of the explanatory model

Evaluation criteria	Assessment
Novelty	The developed model builds further on extant knowledge on AR by relating it to the concept of customer experiences. While customer experience is a commonly employed conceptualization of the competitive logic of retail and has a solid empirical and theoretical basis, the customer experience concept has not been linked directly to AR in previous research.
Credibility	Credibility has been built up through prolonged engagement in the field and the persistent observation and triangulation of data. It has been instantiated by combining multiple sources of data to triangulate findings. With preliminary analysis throughout, the iterative research process has been an effective way of isolating key issues that could be further researched. It has used multiple data sources, including having the view from additional interviews of persons and additional sources such as documentation or observation.
Transferability	Through rich accounts for the respective settings in which the AR solutions were introduced to facilitate the transferability of findings in the cases studied. By searching for sought variance in the devices, retail formats, geographies, and target audiences to expose similarities and differences in the workings of AR and the customer experiences from a retailer and consumer perspective. The model provides transferability via the identified impact mechanisms and the retailer and consumer attributes identified from the cases.
Dependability	Use of initial theoretical framework to organize data. Extensive use of quotes and empirical data to illustrate the key points made in the analysis. In writing case description and analysis, I attempted to let interviewees carry the narrative rather than forcing empirical data into my arguments.
Confirmability	Ongoing auditing throughout the research process has been a way of increasing the confirmability of the research. Initial literature studies were compared with those of fellow researchers or published at academic conferences to ensure an appropriate point of departure. Analyses of impact and design cases were presented at peer-reviewed conferences and workshops. Finally, the quality attributes of the whole research process are evaluated here.

7.2.2 Designing AR using a human-centered approaches model

The explanatory model from Chapter 4 has been extended to incorporate human-centered design characteristics as part of how to design AR with users. This moves from a technology view of AR to a human-centered view based on the cases analyzed in Chapter 4, the maturity of the technology, how it has been used in the customer's shopping journey, and the doubts it creates for the customer (Chapter 5). Using human-centered approaches (Maguire, 2001) to design AR adds to the extant theoretical knowledge. The use of human-centered approaches to design AR has been scarcely researched to date per extant literature reviews.

Two approaches have been introduced in this research: co-creation and design thinking. They engaged users to design AR that were feasible to enrich specific retail customer experiences. Chapter 5 extends the conceptual model to incorporate the iterative human-centered design process. This model, used to analyze the cases, contributes to extant research on how to design AR experiences with user involvement to enrich retail customer experience. Chapter 6 proposes a framework for how AR designers can develop AR solutions with users to have the intended outcomes, based on the findings from the two human-centered approaches used to analyze the cases in that chapter. The study from Chapter 6 shows that with human-centered approaches, one can determine the cognitive aspects and the goals and needs of users and determine an AR solution that supports those needs. These approaches identified bottlenecks in the adoption of AR technology and the need to focus on solutions to solve the most essential characteristics and requirements. The solution would thus be designed to address the specific retail experiences presented via the use cases.

According to Gregor and Hevner (2013, p. 351), "It is important to note that some degree of flexibility may be allowed in judging the degree of evaluation that is needed when new DSR contributions are made; particularly with very novel artifacts, a "proof-of-concept" may be sufficient." Essentially, the general human-centered approach was tested naturalistically (Pries-Heje et al., 2008) by two AR developers targeting retail (IECTS and Infosys). The researcher inferred learnings from the real-world use of the approach to articulate a set of principles for how to use human-centered design in this specific context effectively. This is seen as an initial step to contribute to the extant theoretical knowledge by way of approach evaluation. This should, in subsequent research, be followed by other forms of evaluation, including the additional principles developed in this thesis, in an iterative process of theory development and refinement (c.f. Carlsson et al., 2011). Table 36 evaluates the criteria set out in Chapter 2 to assess the AR Design model from Chapter 5, a key contribution to the extant theoretical knowledge from this research.

Table 36. Evaluating contributions for AR design using a human-centered approaches model

Evaluation criteria	Assessment
Completeness	The model provides an iterative approach that engages users to clarify the business use case scenario. It solicits requirements from the users for what are must-have features, makes sure the technology is a good fit for the solution desired and will be feasible and viable via evaluation and testing of each iteration. This allows users to fully understand what is being designed and whether it addresses the use case and makes the solution usable
Simplicity/Ease of use	By engaging cross-functional teams of users who have different levels of engagement and knowledge with AR technology, and the designers and

	developers of the technology solutions working together iteratively, this model provides opportunities to design feasible solutions, with the users knowing the limitations of the solution in the process
Consistency	The participation of the retailer and different types of customers with the designers and developers allowing for feedback, comments, and opinions in the design process; all understand the objectives as well as the steps to achieve them; videos and overviews of what the technology can and cannot do; visual techniques like customer journey mapping are used for the participants to map out the must-have features to address the retail experience challenge; the prototypes produced are evaluated and tested to make sure the solution is feasible and viable to enrich the specific customer experience use case
Quality of results	The cases analyzed did not include the implementation of the solutions designed using human-centered approaches. However, this approach provided context for how to design quality solutions that included the must-have features to meet the varying needs of the participating users, including the retailer and the customer, and knowing the current technology limitations of AR. The quality results from the design process included the must-be quality elements. These are potential bottlenecks of the solution. Without them, the solution is not feasible, so these had to be addressed. One-dimensional quality elements have a significant impact on user experience and are thus important; hence, the technical solution must be reliable. The cases using the human-centered approaches provided the context for this model, building quality in the iterative process.

7.2.3 Framework of steps to design AR with users

The research identifies a framework of the steps to design AR experiences with users based on the AR design study of two cases using human-centered approaches (Table 34 in Chapter 6). The steps relate to the Type V theory of Design and Action (Gregor, 2006) by providing a rationale for why the technology is needed, a clear understanding of the problem use case, and how it affects the business model being impacted. It includes what the users need, whether the chosen technology addresses the problem and what the users have termed as must-have requirements, and whether the solution creates ease of use, usefulness, and desire. Finally, it evaluates and tests the solution designed to ensure that the desired quality is achieved while knowing the technology limitations. This framework is an initial contribution and should be extended in future research to include the cognitive and emotional aspects of the users based on familiarity, need, task to be fulfilled using the AR technology.

7.3 Practical Implications, Limitations, and Future Research

The research has determined several implications for designers and retail managers, identified limitations, and provided future research opportunities, detailed in the following sections.

7.3.1 Practical implications

The case analyses have demonstrated multiple implications for AR technology designers and retailers. These implications must be addressed with maturity in the technologies and retailers to enhance the customer's retail experience. Table 37 summarizes the implications for the designer and retail manager.

Table 37. Implications of AR in retail customer experience

Stakeholder	Implication	Description
AR Technology Designer	Designing for larger populations	The AR design must account for different types of people, level of familiarity and engagement with the technology, personal biases, and preferences
	Virtual objects fit in the physical world	Augmenting the real world with 3D objects needs to make sure they fit in the place the augmentation is required, and do not block or hinder the physical reality where the augmentation will be experienced
	Level of information presented	Different users need to view and access different levels of information based on their motivation, biases, familiarity, and sensitivity. Designers must develop solutions to cater to these variations
	Personal information	To offer personalized and secure solutions, AR designs access personal information, creating a sense of doubt in the users. The design should have user consent as part of the interaction
	Interactivity	AR design should provide interactivity to the users. Users should be able to participate in modifying the form and content of a mediated environment in real-

		time; otherwise they will not benefit from this immersive technology to make decisions
Retailers	Product choices via personalization	AR can help overcome product choice overload by integrating with AI and RFID / authentication to strengthen consumers' choice confidence by narrowing the number of choices offered to a consumer via personalization and security
	Digitizing customer journeys	AR can be considered drivers for retail experience innovation by attracting and maintaining customer attention and directing traffic toward cross channels.
	Immersive Experience	AR through the characteristics of vividness, information level and interactivity provides options for consumers to experience this technology for utilitarian, hedonic or enjoyment purposes using different devices in different retail settings
	Retail digital transformation	The retailer's business model and digital maturity are important to ensure AR's effectiveness in the customer experience strategy – this cannot be a standalone, disconnected experience un-mapped to strategy.

Implications for AR technology designers

The Saks case demonstrated the need to design smart glasses that cater to both right and left-handed people to account for people who already wear glasses and to contain the heat and power dissipation more effectively. These are critical for continued usage beyond using them for hedonic and enjoyment reasons for making shopping decisions. The implication for designers is to understand customer profiles and variables in wearing headwear to make sure it is comfortable.

Image recognition is one of the essential features of AR. Users expect AR precisely to recognize objects they point their smart devices at. AR must recognize these objects to superimpose the relevant virtual content onto the existing reality.

Another essential factor of augmentation quality is correspondence quality. AR displays virtual content onto reality. Correspondence quality refers to how AR can overlay and map virtual content onto the precise place where it belongs. The LP case indicated that users were concerned about the size and fit in their homes because the augmentation quality was not good. If AR is unable to display virtual content onto the appropriate place, the augmentation quality will be unacceptable.

Information quality refers to the extent to which AR provides relevant and sufficient virtual content to users. The reliability of the virtual information is important, and so is the quantity of information, which should be based on user expectations and requests. Presenting too little information fails to satisfy users who have tasks to perform. Displaying too much information can overwhelm users. Therefore, AR designers need to develop AR applications that display output based strictly on users' needs and desires. The ICETS case showed that different types of customers expect different levels of information content and utilities to search and compare brands and prices.

The control of access to users' personal information has become a significant issue for people using AR technology. Consumers expect AR applications to display personalized output to users, but to do that, AR needs to collect users' personal information. Sometimes users are reluctant to share personal information such as body shape, size, preferences, their name, email address, and location with an AR application because they have no idea how it will ultimately be used. It was highlighted in the Saks case, where users were cautious about using the AR smart glasses for decision making.

Interactivity refers to the "extent to which users can participate in modifying the form and content of a mediated environment in real-time" (Steuer, 1992, p. 84). As technology advances, interactivity becomes an even more integral part of the application. Augmented reality with no interactivity component is similar to obsolete technology that did not enable users to interact with it.

Integration with other digital technologies and social media is vital for customers to eliminate some of the cumbersome touchpoints in their shopping journey. It was illustrated by all of the cases analyzed. That means designers should ensure the integration is frictionless and easy to use from the AR device.

Implications for retailers

AR provides multiple implications to retailers in terms of how they could affect customer experience management via offering products that matter to the customers, creating differentiated immersive experiences in the customer's shopping journey, providing different tuchpoints for customers in the different retail formats and using AR in their digital transformation strategy for how AR could be integrated with other digital technologies to enhance the customer's retail experience online or offline.

Product choices via personalization: Previous research has shown that a greater variety of products on offer can have adverse effects, potentially leading to choice confusion (Garaus et al., 2015). The findings from the Saks, ICETS and Infosys cases indicate AR's potential to enhance consumer choice confusion via personalization and offering product choices that make sense for the customer. We know that if customers are presented with a significant number of options at the consideration stage of the purchase journey, choice overload can negatively influence their ability to choose. The findings suggest that AR can help to overcome this choice overload by integrating with AI and RFID / authentication and may be able to strengthen consumers' choice confidence by narrowing the number of choices offered to a consumer via personalization and security (Saks, ICETS, and Infosys cases).

Digitizing customer journeys: AR strategies can be considered drivers for retail experience innovation (Moorhouse et al., 2017). AR can inspire consumer behavior by attracting and maintaining customer attention and directing traffic toward cross channels. The in-store set-up can provide customers options to virtually try-out, get pricing information, compare choices and brands and then narrow the selection to physically try-out or make a purchase decision digitally; alternatively, they can start online and purchase in-store; or they can be in the online channel and make decisions. Adding digital information, either textual or graphical (all cases), and a means to store selections made in one channel and used in-store or online (Infosys case), gives both functional and emotional extra value to the customer experience.

Immersive Experience: The Saks case examines hedonic values provided by the set-up in the retail domain, via the smart glasses as a fashion accessory, with multiple functions of voice and field vision, and looking more or less like normal framesets. It, therefore, contributes to the provision of the hedonic values of enjoyment and aesthetics. The technology develops a new conceptualization of AR design. It includes smart-glasses optimized for weight, thermal management, and field vision, integrated for user authentication, and providing an ability to select and make a purchase decision in-store. Regarding consumers' acceptance of AR, the Saks case showed that there could be an increased uptake by a broader range of shoppers by making the glasses more socially acceptable (e.g., discrete and subtle), useful, comfortable, and natural to interact. It could even be fashionably acceptable (Carmigniani et al., 2011;

Poushneh and Vasquez-Parraga, 2017). The LP case showed that mobile AR technology offers a strong potential to be an essential driver for consumer adoption. Consumers having the ability to view AR experiences and interact with products through their mobile devices will lower the barriers to adoption because they are already familiar and comfortable with the technology involved (Howland, 2016). From a security and privacy perspective, AR systems, although advanced, at the same time do not protect the user's privacy, thus allowing others to access or see information (Carmigniani et al., 2011). It represents a problem concerning the confidentiality and security of information (highlighted in the Saks and Infosys cases). Traditional in-store shopping, via the Saks case, can stimulate pleasure, enjoyment, and excitement (Hart et al., 2014) while online shopping has been said to offer little experience value (Mathwick et al., 2001). However, more recent research suggests that shoppers also seek out recreational, enjoyable online shopping aspects (such as via the LP case) (Fiore, Jin, and Kim, 2005; Konus et al., 2008).

Retail digital transformation: Retailers are experiencing multiple digital technologies to fuel customer engagement in online and offline retail environments. The need to share empirical cases and findings on a global scale is imperative for retail systems' stakeholders. Because of technology's speed, retailing faces a constant metamorphosis; this research provides evidence via different studies offering ways to adapt to rapid changes. Thus, practitioners can consider implementing specific AR that can provide the experience they seek to deliver. Rather than merely seeing an AR as a way to enhance service, the research illustrates AR's potential to enhance the retail experience (the AR impact and design studies show this promise).

7.3.2 Limitations

This research used different retail settings to address different use cases to understand the potential impact of AR to the retailer’s customer experience management as well as how consumers perceive the experience. It provided for how by engaging users upfront using human-centered approaches in the design of AR solutions, specific retail experiences challenges could be addressed. The research was limited by the qualitative analyses of the cases primarily because of the focus on understanding the nature of the research issues rather than on the number of observed characteristics by interpreting and contextualizing meanings from people’s beliefs and practices in terms of how the user of AR affected their retail experience in the different retail settings. It provided an opportunity to gain an in-depth holistic view of the research problem and facilitate describing, understanding, and explaining a research problem or situation and allowed for human centered design and explanatory focus where the focus is on a contemporary phenomenon using an emerging technology.

The products augmented were primarily clothing, except for the lamps in the LP study. Understanding how this technology could play a role with all of the retail industry's different products and services was therefore limited. The displays were limited by what was available in the AR impact studies though they provided a sufficient basis for showing how the technology can enrich retail experiences. In the AR design studies, the AR technologies were selected based on the underlying design attributes. The technology was limited by its current maturity and how it was integrated with other digital technologies in the customer's shopping journey. The research, via the human-centered cases, showed that it was possible to select AR technologies with the desired integration of other technologies that met specific retail experience challenges.

The studies were conducted in Denmark and the US, and the studies did not address any cultural or social issues specifically. The studies also did not specifically address the retailer's location, brand or storefronts, nor impacts of the political climate, economy, or geography. This is a field of research that can be expanded as AR continues to expand in retail and customer and retailer attributes, as well as economics, political climate and geography become critical differentiators to be studied.

There are challenges with the large scale use of AR at this time due to lack of proven business models, standardized application design and development standards, technology maturity, security and privacy issues, not well articulated use cases or content for AR use, and social acceptance due to ethical and legal concerns. This research provides insights to create meaningful retail experience by engaging retailers and different types of customers upfront using human centered approaches to design solutions that are usable and viable and the nine impact mechasims that both retailers and customers should be cognizant of to enrich retail customer experiences.

7.3.3 Future research

The findings from the AR impact and AR design studies have created multiple opportunities for future research. With the ongoing retail transformation, AR applications promise to play a prominent role in shaping the customer's experience across the customer journey and in different channels.

Contribution to Technology-driven retailing: This research extends the previous research on the impact of new technology on retailing (Demirkan and Spohrer, 2014; Pantano, 2014; Hristov and Reynolds, 2015; Hagberg et al., 2016; Pantano, 2016; Willems et al., 2017; Bertacchini et al., 2017), via the AR impact study, by introducing the concept of shopping as an integrated experience and as an extension of the traditional in-store shopping activity. The research focuses on the evaluation of the effects of AR solutions on the retail customer experience. Moreover, as immersion varied among individuals (Miller and Bugnariu, 2016), based on familiarity, it confirms that an individual's previous exposure to AR or other innovative digital technologies influences their everyday experience. By closely looking at the different business models specific to various technological characteristics available, different engagement values can be offered to customers, thereby broadening the way to understand the benefits of interactive digital technology in retailing.

Customer differentiation based on familiarity: The current AR design study in the ICETS case uncovered that digitally savvy customers had different technology needs than novices. Future research may consider the moderating role of consumers' familiarity with the technology to ensure users' different shopping outcomes and repeat users using other digital integration like AI and Big Data. More customized and personalized AR characteristics could be provided based on the type of customer.

Seamless integration between channels: Because the embedding of digital information into the customer's physical environment is a crucial feature of AR, there is a need to extend the Infosys case findings. The research should investigate which modalities of information (e.g., text, image, or video) and combinations thereof work best for enhancing the customer experience across various channels and interactions with humans or digital assistants at any touchpoint of the journey.

AR beyond physical products: The LP study demonstrated the importance of situational contingencies or the context of use, such as the function or purpose of AR concerning products, and the need to extend AR-based experiences through social networks (e.g., allowing the incorporation of fellow customers and shared decision making). It will not only determine whether customers find the technology valuable but also acceptable. Also, a relatively underdeveloped direction is whether AR can be effectively used to enrich the delivery experience of intangible and co-produced services (instead of physical products).

Providing value-added services in retailing: The Saks case revealed the potential in integrating different digital technologies. With the ongoing digital transformation in retail, AR affords a way to integrate other value-added services that enhance the customer's shopping journey – these could be rewards programs, loyalty programs, discounts, and services based on customer stickiness. To date, this area has not been covered in research on how AR can affect retail customer experience.

7.4 The Future Outlook for AR and How Retailers can Benefit

AR is undergoing many changes as the technologies it relies upon improve to provide better design attributes and more robust integration capabilities. The emerging trends can allow retailers to look at other ways to enrich retailer customer experience[17].

Integration of AI with AR: Artificial intelligence and augmented reality have been regarded as unique technologies however there is a tremendous potential to be integrated. Together, these technologies can use advanced machine learning and other AI methodologies to build highly personalized and interactive environments and improve image recognition. In retail, there are different types of shoppers using different channels and needing multiple levels of information content and the search capability for comparing products based on their personas.

Rise in the number of AR avatars: In the past few years, virtual celebreties have become popular and have appealed to consumers who have become their virtual influencers. Retailers have the opportunity to incorporate these avatars into their business processes to attract users but also to help them in navigation inside/outside the physical store, adding a hint of beauty to their overall experience, and more.

Gearing up vehicles with the power of AR: As autonomous vehicles gain popularity, people are curiously waiting to get into these self-driving cars. This creates a tremendous potential for integration AR into these vehicles for automobile manufacturers. Retailers have an opportunity to present discount coupons for shopping, based on GPS of where the vehicle is, providing for products in a home-like setting in the vehicle. Hence, the driver feels like they are at home while being driven.

5G will speed up AR/VR evolution: The merging 5G will enable super-fast mobile networks to increase the pace of data transfer to the cloud, data processing will be a lot faster to enable the formation of virtual images, to provide an enhanced virtual experience to consumers. There is potential to improve underlying AR technology design as 5G can boost the experience level even in low-bandwidth, low-powered environments. This will make it possible to enjoy a better-augmented experience with cheaper headsets and devices. AR will become more affordable for retailers who today find the solutions

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[17] https://appinventiv.com/blog/ar-vr-trends/ - this article looks at the emerging trends in AR and VR 2020-2025.

https://www.forbes.com/sites/bernardmarr/2020/01/24/the-5-biggest-virtual-and-augmented-reality-trends-in-2020-everyone-should-know-about/#28ac327b24a8 This Forbes article talks to the biggest trends in terms of how AR-VR is emerging and how it is being used expensive or not providing the right level of experience due to network connectivity, bandwidth, or aging infrastructure.

The advent of WebAR: This development will facilitate users interacting with AR in the web space. It will enable them to get exposure to AR on different browsers regardless of which device they run upon, resulting in lower barriers to usage and higher overall experience. Customers can now interact with products and services using AR online or on their mobile devices, providing retailers opportunities to engage more actively using AR with these customers.

Advancement in AR displays: The display of the AR headsets will be magnified with the emergence of high-power content displays on the screen without blurriness or putting a strain on the eyes. These improvements provide retailers more significant opportunities to offer better photorealistic experiences for the customers to engage with to make decisions for purchase while looking for products.

The emergence of AR-based indoor navigation: One emerging trend is using AR for indoor navigation to assist people indoors. This technology will engagingly and effortlessly show people the path towards any particular product, software, or location, giving them an optimal experience without relying on others. It has good relevance for retailers in-store to help customers find specific products, facilities, restaurants, etc. while spending time at the retailer.

8 Conclusion

The emergence of AR has occupied the interest of researchers and practitioners alike across the world. Its echoing impact on the future of retail business can no longer be overlooked. Retailers are increasingly gearing towards the adoption of AR technology within their business streams, shaping how they present their products and integrating the ways by which outstanding service and enjoyable customer experience to customers is being delivered. This research sheds light on the increasing importance of AR for how it could enrich retail customer experience in different store formats using a qualitative method on AR impact and AR design case studies. It demonstrated how AR in retailing impacts the various stages of the consumer journey turning it from a linear to a non-linear one. The research offered specific guidelines on approaches to enrich retail customer experience dimensions based on customer expectations of what the retail experience should be. It used human-centered approaches to highlight what retailers could provide, and the feasibility of AR displays and formats, ultimately leading to higher purchase intentions.

From this research, it is clear that AR can provide retailers with several opportunities to enhance consumers' experience and attract potential users to interact with products and touch them in an augmented way (Brengman et al., 2018). It could lead to increased consumer engagement (Javornik, 2016a, b), enhance product tangibility (Vonkeman et al., 2017), and increase the willingness to buy. Thus, increased interest in AR in retailing among researchers and practitioners is most likely to continue. However, AR is still in the nascent stages for retailers and business-oriented research, and there is an excellent scope for further development. The customer experience will become a big challenge for retailers in the future. The integrated shopping experience will dominate many retail markets through AR with other value-added services like that make the interactions safe and secure and will play a pivotal role in the future of retail experience. There are many reasons for the promising future of AR in retail.

User experience: AR creates a superior user experience by providing an in-store experience irrespective of the customer's location. The technology, via integrating with AI and RFID technologies, can provide contextual and personalized products and services while protecting the privacy for the consumer. Customers can use AR to superimpose a product or service depending on the need and find the optimal choice to suit their requirements.

Reduced operational cost: The efficient use of AR in an integrated shopping system can significantly reduce the retail store operating cost. An AR-powered decision will reduce the product return ratio significantly. The number of in-store employees will decrease with the implementation of AR technology. It also provides opportunities for retailers to not have to stock everything in-house and have high inventory and supporting personnel.

Collection of customer behavior information: With the help of AR technology, retailers can get more detailed information about choices, interests, size, and other kinds of data, which can be utilized to increase customer engagement and loyalty. The future of the retail experience will rely on better business intelligence. AR will help collect the right business information and help retail stores create a competitive edge over their competitors. This is possible by integrating AR with peer reviews, AI, RFID and BigData technologies as well as how customers choose to pay for the products and have them delivered.

Improved personalized product ordering: AR will help customers to order personalized products more efficiently. An AR-powered mobile app can easily take a personalized order by taking the customer's right and correct choice. It enhances the customer experience and satisfaction, and the productivity of retail stores, thereby enhancing the retail experience.

The success of AR solutions depends on how well developers account for human aspects and how that influences technology acceptance and user experience to make decisions. A close collaboration with users is essential to design AR solutions that the users will accept to perform different tasks that add value and enriches their retail experiences. Security and privacy issues also play a significant role (Roesner, Kohno, and Molnar, 2014; Roesner et al., 2014). The customer and the expected retail experience will have a significant role in the development of AR solutions and should be the focal point of the solution development process (Helkkula, Kelleher and Pihlström, 2012).

The research demonstrated that AR could increase value during and between touchpoints in the customer's shopping journey. It can also reduce value depending on how it is implemented and received from the customer's perspective. Customers can form negative impressions based on initial experiences, disjointed journeys, or friction while interacting with AR. Value creation is likely to occur when digital technology supports the customer's current goals or desires, facilitates meaningful interpersonal relationships, and enhances the customer experience. Therefore, retailers' good use of digital technology can strengthen customers' willingness to visit or return to retail stores in different formats.

The studies showed that we live in a customer-driven world, where the informed customer, not the retailer, can dictate much of the desired experience. No longer can retailers be passive observers and hope their product content finds the right shopper. This was demonstrated in the Saks and LP AR impact cases and the Infosys Design Thinking case. Retailers must be able to serve consumers with immediate and personalized content, anytime and anywhere. Current AR technology strategies to deliver an immersive, customized shopping experience, improving flow among consumer touchpoints, and providing content that has an emotional and cognitive fit, can provide this level of service.

There are multiple avenues for the research to be extended with the continued maturing of AR in retail and what this implies for retailers and customers via the technology trends. It provides integration opportunities with IoT, AI, Blockchain, cryptocurrencies, other value-added services, etc. that can transform customer shopping journeys and the dynamic touchpoints that emerge in a personalized way. Secondly, it provides opportunities to strengthen ways to engage users upfront to design and develop AR set-ups in retail, meet the desires of retailers and customers, establish what is feasible, and design and develop viable options. The qualitative constructs, the theoretical framework, and the conceptual model developed from the studies could be used for quantitative and mixed-method analysis as AR becomes mainstream, and its acceptance and adoption increase. Thirdly, the research could be extended to different locations, socio-economic diversities, cognitive and emotional attributes, demographics, and cultures to understand how immersive experience affects diverse groups. Given this is an emerging technology, it might make sense to continually engage practitioners who are using AR in different settings into academic research to extend the knowledge sharing and learnings further. That would strengthen the development and use of AR in retail to enhance the retail experience in different formats and settings.

This research was exciting and a great learning experience in multiple ways. It provided context and a broad view of the retailing industry, its challenges, and the transformation journey retailers are on for multiple reasons. It gave an increased understanding of AR's potential to provide and add value for customers in the engagement and experience of their shopping journeys. It also showcased the immense potential for retailers to continue to transform across products, services, and channels.

This thesis is a starting point for continued research in moving AR technology from how it has been employed today to how AR-based customer experiences will become vital in transforming retail and customer experience across different channels and formats. Interestingly, the pandemic has created a more purposeful need to accelerate the digital transformation in multiple businesses and AR is one of these technologies that holds a strong place to drive this transformation in the new normal being formed.

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Appendix

Appendix 1

Published Papers

Though this was a monograph based thesis, several papers were published to highlight the areas of research in different conferences and learn from other researches in terms of findings, learnings for AR is being used in the different domains as well as its growing interest in the theoretical space. The papers that were published during this research period are in the areas of literature review, the AR impact studies, and in the user involvement of AR technology selection.

Paper 1: C. C. Hofma, S. Henningsson, and N. Vaidyanathan, "Immersive Virtual Environments in Information Systems Research: A Review of Objects and Approaches," in Academy of Management Proceedings, 2018, vol. 2018, no. 1, p. 13932: Academy of Management Briarcliff Manor, NY 10510

Paper 2: Vaidyanathan N. (2020) ICVARS 2020: Proceedings of the 2020 4th International Conference on Virtual and Augmented Reality Simulations February 2020 Pages 27–34https://doi.org/10.1145/3385378.3385383

Paper 3: Henningsson, Stefan; Vaidyanathan, Nageswaran; Archibald, Philip; and Lohse, Mark, "Augmented Reality and Customer Experiences in Retail: A Case Study" (2020). AMCIS 2020 Proceedings. 18.
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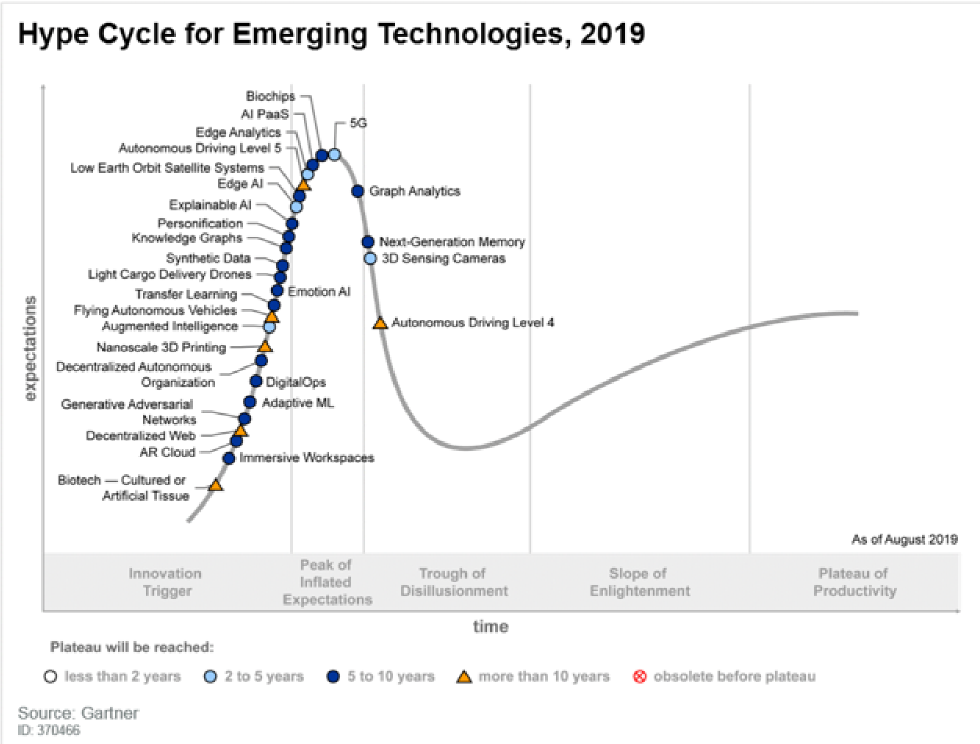
Paper 4: Vaidyanathan N. (2020) Augmented Reality Technologies Selection Using the Task-Technology Fit Model – A Study with ICETS. In: Rocha Á., Adeli H., Reis L., Costanzo S., Orovic I., Moreira F. (eds) Trends and Innovations in Information Systems and Technologies. WorldCIST 2020. Advances in Intelligent Systems and Computing, vol 1160. Springer, Cham. https://doi.org/10.1007/978-3-030-45691-7_61

Appendix 2

Hype-cycle for Emerging Technology perspectives on Augmented Reality



The hype cycle for emerging technologies from Gartner (2019) and the trend of interest in AR worldwide shows that the technology is still not scalable and has not reached its plateau. Gartner predicts it will be 5-10 years for AR to reach its plateau. The hype cycle for display and vision also from Gartner shows that AR is climbing up the slope of enlightenment (there is promise) however it will be 5-10 years before it is adopted mainstream. This data further strengthens the need to continue to research AR potential in retail. While AR continues to mature as a technology it is interesting to note the large number of movements happening in this space across different suppliers for components of AR system. The table below highlights the two years of key shifts happening. Key movements in the AR space (2017-2018) as it continues to become more relevant and mainstream.

Source: Gartner (September 2018)

Date	Event	Value Chain	Impact
August 18	Magic Leap launches Magic Leap One	Hardware	High-profile HMD provider releases first device to market after significant technology pivot
July 18	Amazon launches Part Finder	Software and apps	One of the few high-value, consumer-facing applications of AR seen to date

June 18	Qualcomm announces Snapdragon XR1 Platform	Hardware	First dedicated silicon to optimize immersive experiences and leverage AI capabilities
June 18	Adobe launches Aero	Software and apps	AR authoring tool from leading multimedia software company
June 18	PTC acquires Waypoint Labs	Software and apps	AR workflow capture, creation and distribution tool
June 18	Apple announces ARKit 2.0	Platforms and tools	Key AR features added, including face tracking, more realistic rendering, 3D detection, persistence/shared experiences (for true multiuser AR)
June 18	Unity offers AR Foundation	Platforms and tools	APIs for developers to more easily support ARCore and ARKit
May 18	Microsoft introduces SharePoint spaces	Software and apps	Brings enterprise, web-based collaboration into the immersive space by allowing MR content sharing
May 18	Facebook adds AR to Messenger bots	Software and apps	Adds AR experiences for Messenger chatbots via Facebook Camera
May 18	Google adds AR to Maps and for Instant Apps	Software and apps	Leverages camera for live-feed interaction with Maps and Street View data for wayfinding and ARCore support by Instant Apps
May 18	Microsoft launches Layout and Remote Assist	Software and apps	AR enterprise tool offering from leading immersive platform provider
May 18	ARCore adds additional functionality	Platforms and tools	Key AR features added, including Cloud Anchors (for shared experiences) with compatibility across ARCore and ARKit
April 18	Snap launches second generation of Spectacles	Hardware	Increases awareness for AR and consumer HMDs driven by leading messaging provider
April 18	HoloLens updated	Hardware	New features introduced for highest-profile MR HMD available
April 18	Mozilla launches Firefox browser for AR/VR	Software and apps	Cross-platform browser for immersive HMD experiences
Date	Event	Value Chain	Impact

April 18	Vive provides AR SDK	Platforms and tools	Added functionality is tacit recognition of the long-term convergence of AR and VR functionality and experiences
March 18	Toshiba announces dynaEdge AR100 Head Mounted Display	Hardware	One of the few Windows 10 AR HMDs (powered by dynaEdge DE-100 Mobile Mini PC)
March 18	DAQRI announces Worksense	Software and apps	AR enterprise tool platform to support smartglasses HMD, with refocus and emphasis as an end-partner integration enabler
March 18	Google Lens introduced to Android phones using Google Photos	Software and apps	More widely available later in year (iOS, stand- alone app)
March 18	L'Oreal acquires ModiFace	Software and apps	Smart mirror application acquisition highlights growing interest in immersive technologies from leading organizations, including consumer-facing ones
March 18	Facebook enhances ARStudio with AR Target Tracker and image recognition to its AR camera platform	Platforms and tools	Allows for tracking and identification of real-world objects via the Facebook Camera app
March 18	Snap buys PlayCanvas	Platforms and tools	Highlights the importance of game engines in immersive development
March 18	Apple adds AR modules to Swift Playgrounds	Platforms and tools	Highlights the growing importance of AR interface and related skills
February 18	WebVR becomes WebXR	Platforms and tools	Recognition of the shared elements and the eventual convergence of immersive technologies
January 18	Flex launches AR reference design for HMD glasses	Hardware	Lowers barrier to entry and time to market for HMDs

December 17	Vuzix announces Blade	Hardware	First Alexa-enabled HMD
December 17	Qualcomm announces Snapdragon 845	Hardware	Smartphone processor optimized for immersive experiences and leveraging AI capabilities
December 17	Microsoft introduces Simplygon Cloud	Platforms and tools	From Simplygon acquisition — software for automatic 3D model optimization
December 17	Snapchat launches Lens Studio	Platforms and tools	AR content creation and publishing tool
November 17	Apple acquires Vrvana	Hardware	Positive indicator of Apple’s rumored launch of own HMD
November 17	Amazon launches AR shopping tool	Software and apps	One of the few high-value consumer-facing applications of AR seen to date
November 17	PTC acquires Reality Editor	Software and apps	Extends PTC Vuforia offering with content creation and editing tool
November 17	Google launches Poly	Platforms and tools	AR and VR object library
November 17	Apple acquires InVisage Technologies	Platforms and tools	Image sensor company
November 17	Amazon announces Sumerian	Platforms and tools	Platform to build immersive applications
November 17	Williams Sonoma acquires Outward	Platforms and tools	Highlights growing interest in immersive from leading retailers and the importance of 3D imaging
September 17	Apple acquires Regaind	Platforms and tools	Computer vision company specializing in photo image analysis
August 17	Atheer acquires SpaceView	Software and apps	Extends and enhances Atheer’s AR enterprise tool (AiR Enterprise) offering
August 17	Google announces ARCore	Platforms and tools	Raises AR consumer awareness and developer interest for AR on No. 1 mobile OS platform
July 17	Ubimax announces Frontline	Software and apps	Unifies four turnkey modular solutions into a single platform and technology stack

June 17	Apple announces ARKit	Platforms and tools	Raises AR consumer awareness and developer interest for AR on leading mobile OS platform
May 17	Upskill acquires Pristine	Software and apps	Extends and enhances Upskill’s AR enterprise tool offering (Skylight) for remote expert assistance
January 17	DAQRI launches Smart Glasses	Hardware	Initially focused on a helmet form factor, this is a long-awaited HMD offering from DAQRI
January 17	Mozilla launches AR app	Software and apps	WebXR Viewer (iOS) to make and view AR experiences using web technologies and ARKit

Appendix 3

A summary of illustrative AR use cases in Retail

Area	Retailer	Description
Apparel	Zara	• After downloading the Zara AR app, customers can point their phones at the aforementioned shop window, as well as "via in-store podiums, on boxes they receive delivering online purchases and via dedicated images at zara.com," and models Léa Julian and Fran Summers are brought to life for seven- to 12-second sequences. In the clips, the two present the current Studio Collection by posing, moving, and even talking, offering up an oddly realistic experience. All looks shown can then be ordered directly at the touch of a button or bought locally in the store. And, according to a release, "the app features a tool for sharing the experience on social media, encouraging users to take and submit photos of the holograms, establishing a virtual connection that appears remarkably real
Cosmetics	Loreal	• The L'Oreal Makeup Genius app lets customers try on makeup, blend different shades on their faces, and mix products to get the results they want. By scanning the product's bar code in a store or selecting the product online, the app will apply it to the customer's face using Augmented Reality. L'Oreal owns Modiface, the company behind Sephora's Virtual Artist app.
	Charlotte Tilbury	• Charlotte collaborated with software solutions provider Holition and Augmented Retail Solutions to bring an AR experience to customers using a "magic mirror," concept that allows customers to virtually try on makeup in an AR mirror before making their purchase.
Footwear	Lacoste	• Through their mobile app, LCST, customers can select their favorite shoes for a virtual fitting. The app also creates engaging and interactive in-store signage and window displays using AR technology. • Lacoste intends to target the youth with their LCST app, and they've had a positive response, with more than 30,000 users engaging with 3D products on the platform.

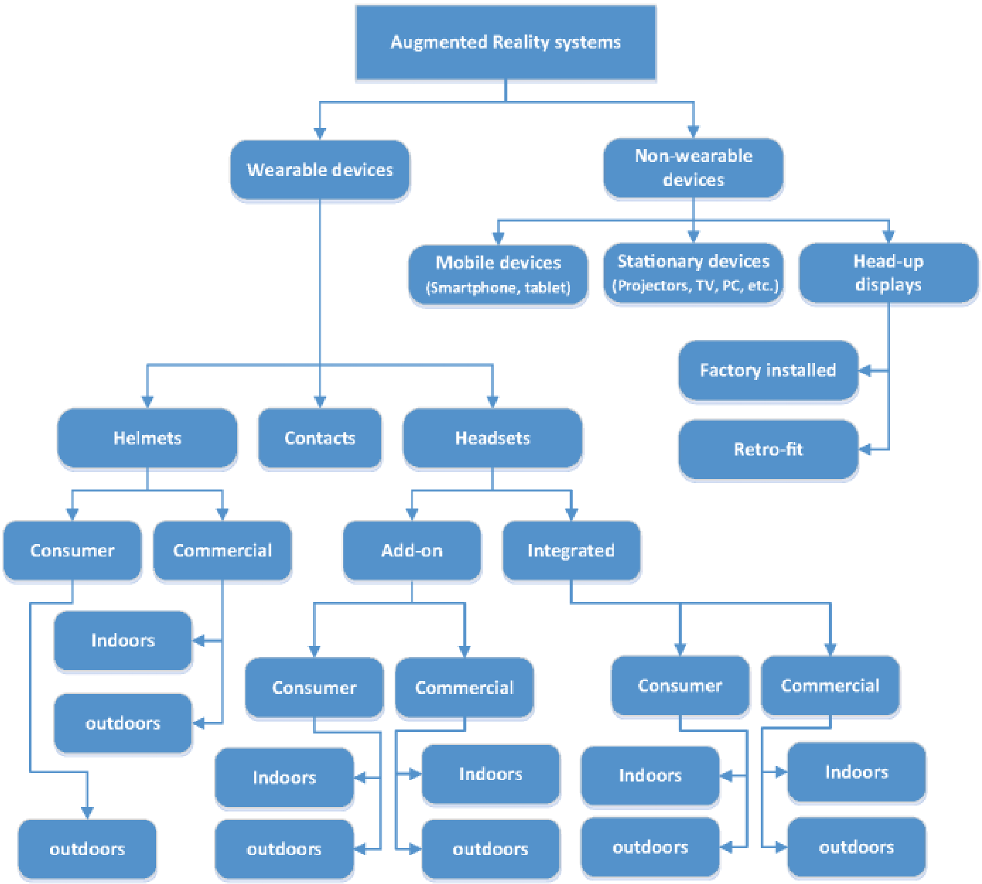
Area	Retailer	Description
Food & Beverages	Coco Cola	• Soft drink leader Coca-Cola teamed up with AR developer Augment to help solve a typical problem that plagued its B2B sales department: visualising how beverage coolers would look and fit in retail stores. Seeing a catalogue or website full of cooler options is one thing; bringing them to life and seeing how a fully stocked, completely merchandised display fits at the end of an aisle is another. • Coca-Cola's use of AR allows potential B2B customers to browse every possible option for their store. By simulating soft drink coolers of different shapes, sizes, and designs, the sales team helps its customers make better product decisions. Even better, Augment's app for Coca-Cola integrates directly with Salesforce, allowing clients to capture photos of every single purchasing option
	PEZ	• Austrian sweet brand Pez, famous for its iconic dispensers, has partnered with AR firm Zappar to enable consumers to interact with PEZ characters via AR experiences in the new PEZ Play app. • When the app is downloaded, gamers are invited to help restore 'PEZ World' to its former glory by finding Candy Codes that appear on PEZ refill pack inlays. Scanning a Candy Code unlocks one of six games and characters, including timing and skill-based challenges and puzzle games

Area	Retailer	Description
Furniture	IKEA	• In 2016, Ikea, the world's largest manufacturer of furniture, generated a global revenue amounting to approximately 35.7 billion euros, a massive increase in revenue compared to previous years. Much of the credit for this increase is due to Ikea's AR app that saved people a visit to the store. • Ikea Place takes the guesswork out of the shopping experience by allowing a user to scan the area of the home they want to buy new furniture for. The app then shows the user how the furniture will look in their space.
	Decor Matters	• Decor Matters mixes game design with serious home decorating tools that aim to keep shopping for new furniture and homegoods fast and easy. The application allows users to create DIY design projects — start from scratch, or converting existing design concepts from Pinterest, Houzz and Instagram — and provides "inspiration pages" to keep users motivated and trying new design options. Decor Matters AR feature allows users to preview their homegoods upgrades in their own space, allowing the shopper to judge fit and how well the new items with mesh with the existing design. Decor Matters includes millions of home furnishing options from renowned retailers like Target, Overstock, Crate & Barrel, Pier 1, West Elm, IKEA, Ashley, and more.
	Amazon Showroom	• Amazon Showroom is the new feature lets online shoppers place 3D images of furniture into a virtual room to get a sense of how it would really look. The room's wall colors can be changed, as well as the carpet and flooring. In addition to seeing how furniture looks in rooms with other colors and flooring, shoppers can add products and entire room designs to the room and then purchase it. The new feature works with both Amazon's mobile app and online

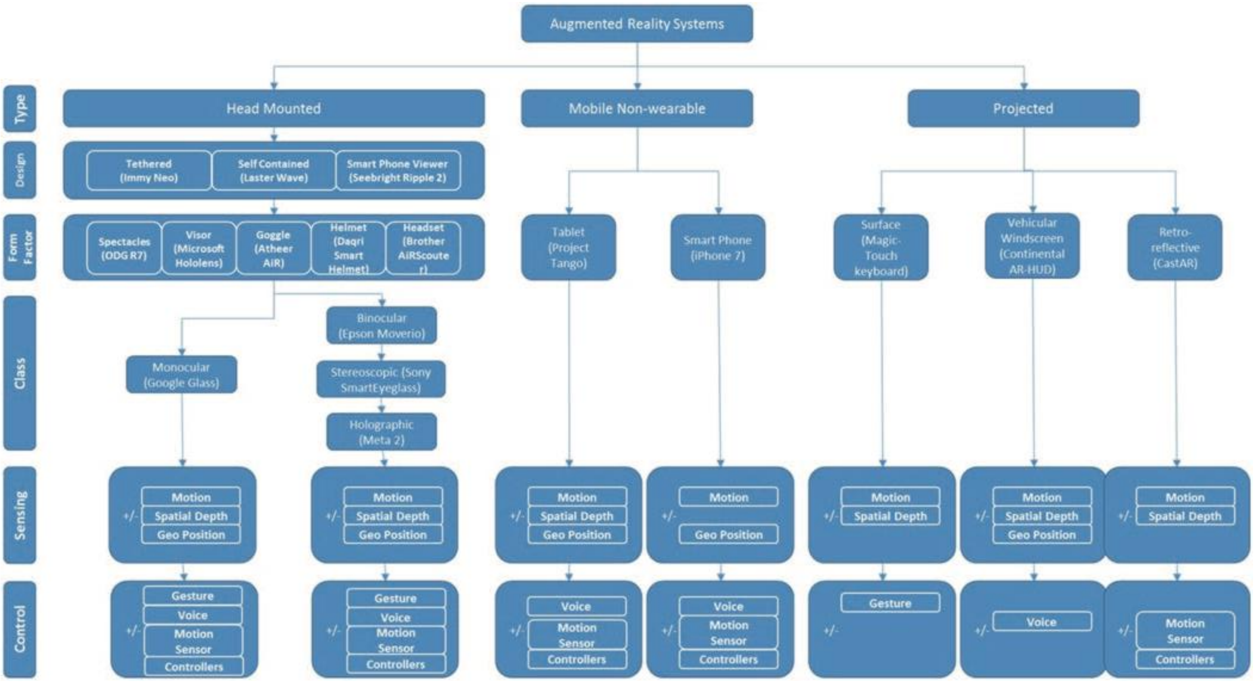
Appendix 4

Augmented Reality Topology, hardware and how it works

Augmented reality is a diverse, robust, and complicated field. At a high level, it starts with two main categories: wearable and non-wearable (portable or stationary devices). Wearable includes headsets, helmets, and one day, contact lenses. Non-wearable includes mobile devices (smartphone, tablets, notebooks, etc.), stationary devices (TVs, PCs, plays, etc.), and head-up displays (integrated or retrofitted). The figure below outlines the taxonomy of the augmented reality field.



Another view of the taxonomy from a hardware standpoint is shown below. This view illustrates the types of Augmented Reality devices with examples of suppliers and hardware components for each type of device.



Taxonomy of augmented hardware (Ron Padzensky)

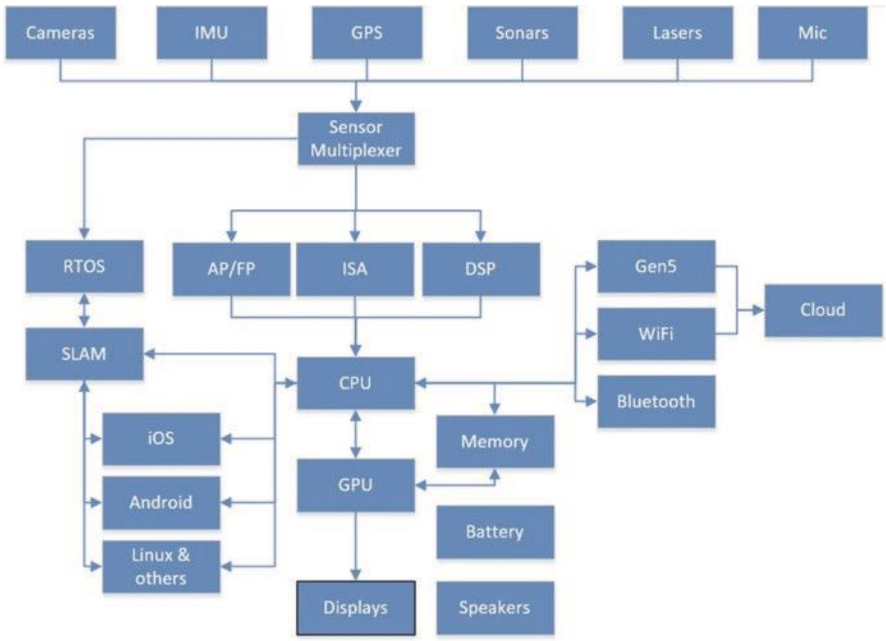
Overview of Augmented Reality systems are organized

The following block diagram shows the relative arrangement of the components of an augmented reality system.

- Cameras—augmented reality devices will always have at least one camera in the visible spectrum, and may have two for depth sensing. There may also be an infra- red (IR) camera in the device, used for heat mapping and/or depth sensing.
- IMU—Inertial measurement unit, used as a gyroscope. It is a gyroscope, Accelero- meter and often Magnetometer combined.
- AP/FP—Application processor/function processor, fixed function engines, task-specific.
- ISP—Image signal processor (for camera output).
  DSP—Digital signal processor (for cameras, mic, range finders, and radio). GPU—Graphics processing unit, also called the Image Generator (IG).
- For augmented reality the GPU needs to do alpha blending to make the objects appear to be in the room over real objects, and while the computational requirements are lower in terms of total scene polygons, the requirements for antialiasing and lighting are higher.
- RTOS—Real-time operating system.
- SLAM—Simultaneous localization and mapping (SLAM) is the computational problem of constructing or updating a map of an unknown environment. In some designs the SLAM is part

of the ISP. SLAM allows an entity to track its location while simultaneously mapping its surroundings.

- MEMs—Micro Electro Mechanical systems used for miniature gyroscope-like sensors.



Block diagram for Augmented Reality system and what it contains

The IMU and GPS help tell the user where they are, as well as provide location information for an external database. The sonar and laser provide depth information, sonar for nearby, and laser for distance. The output is a display and audio. Not all augmented reality systems will have depth measurement capability, most mobile devices for example don’t, and industrial helmets probably will not.

Processors used in mobile phones and tablets known as a system on a chip (SoC) contain a CPU, GPU, ISA, AP/FP, and usually a sensor multiplexor. Mobile phone semiconductor suppliers also make the radios (Gen5, Wi-Fi, Bluetooth), and of course a smartphone or tablet contains cameras, mic, speaker, and display; some even have 3D sensing sensors. Most SoCs have a built-in DSP allowing faster matrix operations.

The device’s main operating system (i.e., iOS, Android, Linux, or some other) are selected by the device builder. The Real Time Operating Systems can be embedded in an AP/FP, or as a Kernel in the main OS.

Appendix 5

Case study interview template

Introduction letter

This interview is part of a case study on the proof of concept that I am performing as part of doctoral research into implications of immersive virtual environments in retail and how that affects customer experience. I am interested in your experiences from the test especially your opinions on the conditions that led to the proof of concept. The interview time is approximately 1.0 hour but may be more or less depending on the details and content flow. All information will be held in the strictest confidence. Only aggregated and non-attributed data will be used in any subsequent publication.

I am also attaching the proof of me being a Doctoral student at Copenhagen Business School.

I will contact you with my paper draft for feedback as well as ensure correctness of the details.

Overview

- *What is Mastercard Labs?*
- *How do they engage in Innovation? What are the measures of success? What are your main experiences on these kinds of proofs of concepts?*
- *Tell me briefly about your experience with Innovation overall?.*

The Proof of Concept

- *How was this proof of concept set up? Partners?*
- *What was the role of Mastercard in this work?*
- *What was the scope of the test? What factors were being tested?*
- *Is it ok if I draw a theoretical model that I can review with you?*
- *What questions are being tested with the set up?*
- *What was the size of the team? Roles played?*
- *What was the success criteria? Was it time-boxed?*
- *What were the learnings? Can the learnings be extended into future work?*
- *In your view was this a successful proof of concept?*

Follow up

- *Is it ok for me to reach out to you via email or calls to gain clarity after I interpret the inputs you provided?*

Appendix 6

Case Study Protocol

Select case

- *Contact the engagement manager of Mastercard and request access to the work done in the labs.*
- *The engagement manger provided some links and then access to the Labs R&D leader for an initial conversation. From there via exchange of notes and calls we determined the proof of concept that made most sense for my paper.*

Identify key project informants

- *Access to the key individuals who were available for questions and interviews. This is detailed in the data collection section. Mastercard also provided access to press releases and videos related to the chosen study.*

Overview of project

To establish substantial description of the proof of concept

Questions.

- *What was the proof of concept?*
- *What questions did this attempt to address?*
- *Was this technology focused or also included impact on how individuals used and experienced the AR set up?*
- *What outcomes were being proved?*
- *What were the hypotheses that was part of the set up?*
- *Was Mastercard ok with reviewing the outputs and providing feedback?*
- *Was Mastercard ok with me using content and quotations from:*
    - *Press releases*
    - *Public Announcements*
    - *Media Briefings*
    - *Event updates from Money2020*
    - *Interviews with technology magazines*
    - *Understand others who would provide content from the Labs or go via single point of contact.*

Framework

Agreed to establish the framework for how I would do the interviews and observations as well as include external content to supplement the learnings and how this influenced the overall paper content.

Appendix 7

Interview guide of the semi-structured interviews

Interviewee Name and role:

Interviewer:

Q1 Why does LP want to use AR as a part of their marketing campaign?

Q2 What are the benefits, in your opinion, of using AR?

Q3 Why have you chosen AR compared to other marketing channels or technologies?

Q4 What kind of business value do you hope to achieve by using this technology?

Q5 What is the objective of using AR and what kind of 'problems' or 'issues' do you wish to address?

Q6 How would you expose your users to this application?

Q7 How are you going to measure this as a success? What are your KPIs?

Q8 In regards to your products, how does LP position itself in the market?

Q9 How does this affect the retail format and marketing mix?

Q10 What are other digital technologies in use at your retail outlets? Will this be integrated?

Appendix 8

<u>Interview Guide for ICETS semi-structured interviews</u>

Interviewee: Name and role

Interviewer:

Location:
Mode of interview: Face to Face, Phone or email

Q1 How do you Identify the need for the AR technology based on the retailer's digital maturity and settings?

Q2 How do you select a potential business model to deploy the AR solution?

Q3 What are the ways you Identify user requirements with participatory & user-centered approaches? Do you do these at ICETS or at the retailer facility?

Q4 How do you consider the characteristics of the AR solution that should be designed or extended or integrated?

Q5 How do you select a feasible subset of features and a business model, given not all user wishes to improve the retail customer experience are to be fulfilled?

Q6 How do you develop a technical solution? Do you use other technology partners?

Q7 Where do you make the decision for other digital technologies to be integrated into the AR solution?

Q8 How do you evaluate and test the solution

Q9 How do you recruit and interview to involve all actors in the development of a digital service in accordance with co-creation methods to make sure is valuable?

Appendix 9

- What are the different types of AR devices developed by ICETS?
- What is the underlying mode for rendering the display?
- What is an example of the device used?
- What formats are used for the device being solutioned – Mobile, Online, Wearables, Interactive, Multi-user?
- What are the AR characteristics considered? Brightness (Adjustable or Fixed), Contrast (Adjustable or Fixed), Field of View (Limited, Extensible or Fixed), Full color (Available, Limited, Not available), Stereoscopic (Yes or No), Dynamic refocus (Available or not available), Occlusion (Yes or No) ?
- Is there Power economy available (Yes / No)?
- What are the opportunities for AR solutions that are current, emerging or not existing but needed?
- What have been the main use of AR solutions in retail? Experimental, PoC, Active Use?
- What are the key barriers for use of AR? Geographic, Social, Cultural, Demographic?
- What are the technology drawbacks? Indicate all that apply
- Anything else I should know about the AR technology solutions?

Appendix 10

Infosys Focus Group moderator interview

1. Primary question: This first open-ended question initiates the entire discussion.

Example:

We are here to discuss ____. What are your thoughts about it?
Have you heard about AR? Why do you think this is a good technology?

2. Probe questions: These questions dig deeper into the discussion of the primary question.

For example,

What do you know about ____?
How familiar are you with this AR technology?
What do you love about what you do?

3. Questions to follow-up: After establishing the overall knowledge and feelings of the group, the moderator identifies specific insights.

For example:

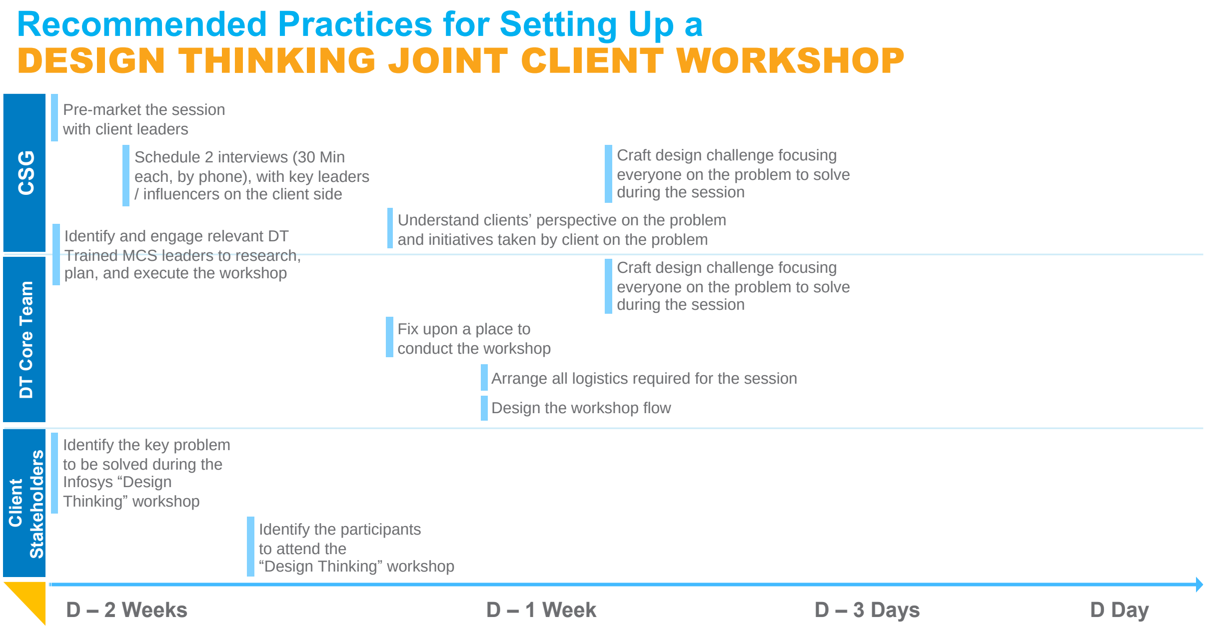
What do you think are the pros and cons of this technology?
According to you, where can we improve to provide better customer experience?
Which factors prompted you to think of the AR technology to address your challenges?
What is the likelihood of recommending this solution to your friends and colleagues?

4. Questions for the conclusion: Review previous questions to avoid overlooking the main points. It is the time when a moderator can revisit specific topics to gather more data.

For example,

Is there anything other than the already discussed questions you would like to talk about?
Do you want to add to what is already spoken about?

Appendix 11



Recommended Practices for Setting Up a
DESIGN THINKING JOINT CLIENT WORKSHOP
CSG
Pre-market the session with client leaders
Schedule 2 interviews (30 Min each, by phone), with key leaders / influencers on the client side
Craft design challenge focusing everyone on the problem to solve during the session
Understand clients' perspective on the problem and initiatives taken by client on the problem
Identify and engage relevant DT Trained MCS leaders to research, plan, and execute the workshop
DT Core Team
Craft design challenge focusing everyone on the problem to solve during the session
Fix upon a place to conduct the workshop
Arrange all logistics required for the session
Design the workshop flow
Client Stakeholders
Identify the key problem to be solved during the Infosys "Design Thinking" workshop
Identify the participants to attend the "Design Thinking" workshop
D – 2 Weeks
D – 1 Week
D – 3 Days
D Day

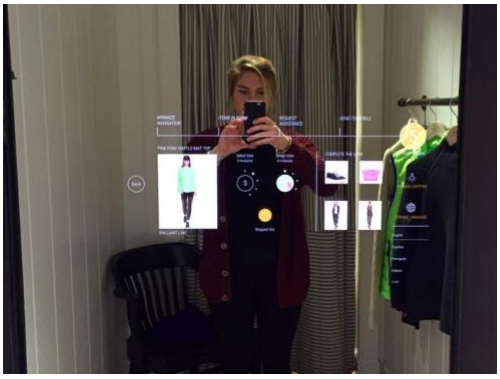
Appendix 12

A customer journey for how the smart mirrors was used at RL is highlighted below – this is based on customer's feedback experiencing the AR set up in the fitting room at RL in NYC.

I went to Ralph Lauren's Polo flagship store on 5th avenue in Manhattan to check out a cool new feature that was added to the store

Customer walking into the RL store

After picking out some clothes to try on, an employee led me to the fitting room where I was excited to find the interactive mirror

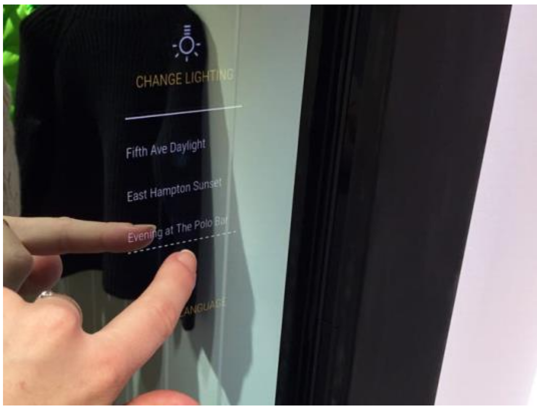


Installed smart mirror

It's a touch screen — similar to an iPad or tablet — and includes all the necessary features shoppers might need while trying on clothes. When I entered the fitting room, all of the items I wanted to try on were already scanned and entered onto the interactive mirror

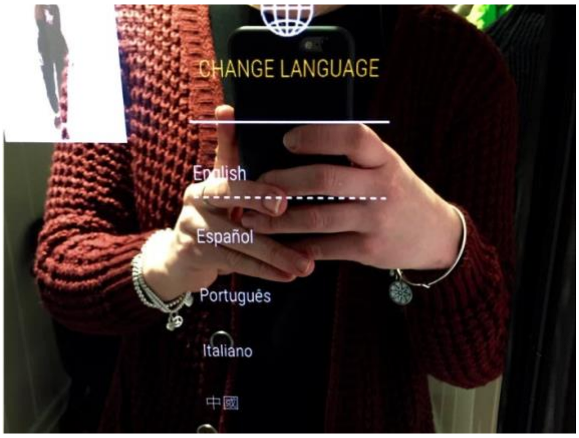
Interactive smart mirror features

Before trying on the items, you can set the lighting of the fitting room to your liking. The lighting ranges from brightest to darkest and the options are called "Fifth avenue daylight", "East Hampton sunset", or "evening at the Polo Bar". I'm not a fan of fluorescent lights so I went with the darkest setting



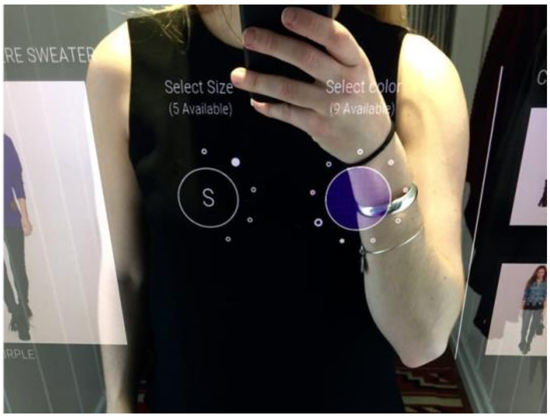
Choosing the fitting room ambiance

Next, you can choose the language you wish to use



Choosing language to communicate, search

If the color or size of your item isn't working for you, you can choose something different from the options on the mirror

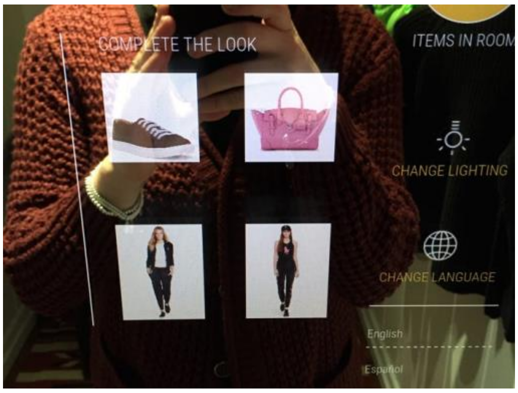


Choosing product options with context

...and an employee will respond to you! You don't even have to leave the room. They'll grab the new item and let you know when they're on their way.

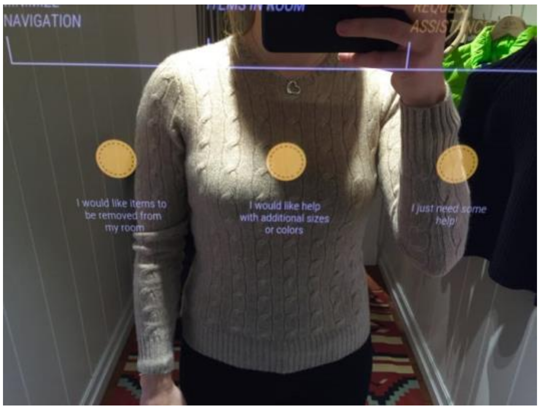
Integration with text messaging

The mirror will also double as a personal shopper by recommending other items that might go with what you're trying on. This is a smart way to get shoppers to spend more money



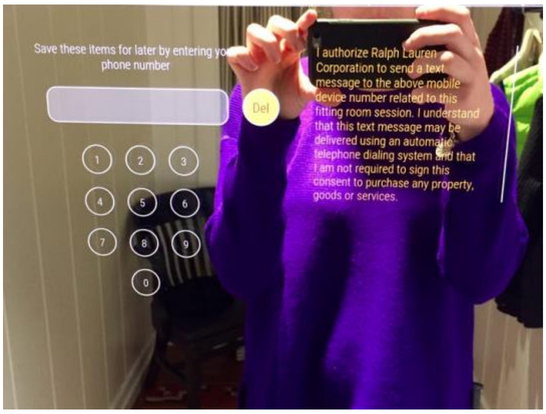
Product choices to go-with - upsell

*If you press the "request assistance" feature, you can choose to remove items from the fitting room, swap sizes or colors, or just talk to someone (if you feel like engaging in human interaction)***.**



Interaction with store employee

When you find something you like, but aren't sure if you want to buy it that day, you have the option to send the information about that item to your cell phone. The mirror will text you.



Track product choices for purchase later

¨My first experience using Ralph Lauren's interactive mirror was awesome! It made my shopping experience so much better. I didn't have to worry about getting dressed to go back in the store to find a different size or color. And it was cool to browse through other items without leaving the fitting room. My favorite part was being able to set the lighting — a constant nuisance in most dressing rooms. Hopefully smart mirrors will be in every fitting room in the near future.¨

Customer Experience summarized

ERRATA

¨Enriching Retail Customer Experience Using Augmented Reality¨ – Nageswaran Vaidyanathan

No.	Page Number	Chapter / Section	Current Text	Error	New Text
1	22	2.1	Macguire (2001)	Wrong spelling	***Maguire (2001)***
2	31	2.4	Exce	Incorrect spelling	***Excel***
3	32	2.5.1	ODG that develop the smartglasses	Wrong word	ODG that ***developed*** the smartglasses
4	38	2.5.3	semi-structured interviews with customers to directly examine	Extra words	***semi-structured interviews with Mastercard to directly examine***
5	44	2.6.2	was approached by	Wrong wording	***had a case for study***
6	74, 75	3.3.2	¨ Early research into AR, with interactive displays used in a physical retail environment, predicted users interacting with a steerable technology and…… perceived as an innovative player by consumers and competitors (Bonetti et al., 2017)¨	Missing reference	Add ***Bonetti, et al. (2018) in their paper, have provided multiple perspectives on the use of AR in retail and have been referenced verbatim in the four paras below***. Add this sentence before ¨ Early research into AR, with interactive displays used in a physical retail environment, predicted users interacting with a steerable technology and……
7	83, 87	3.4.2	Havif (2017)	Wrong spelling	***Havíř (2017)***
8	83	3.4.2	Missing reference to paper by Havíř (2017)	Missing reference	Add ***The customer experience models and frameworks described below are referenced from the paper authored by Havíř (2017).*** after the sentence The dimensions of some models are more concrete and focused on the customer as an emotional human being; some, on the other hand, focused on the process of acquiring goods or services.
9	87	3.4.3	Missing reference to Hilken, et al., 2018	Missing reference	Add: ***Hilken, et al., (2018) in their paper provide multiple insights for possibilities related to use of AR in the retail domain and some of their insights are referenced below***. after the sentence …. AR took place via smartphones and tablets (Javornik, 2016; Rauschnabel, 2018).
10	90	3.4.4	Add footnote to refer published paper	Missing reference	Add footnote to section heading Appendix 1 Paper 3: Henningsson, Stefan; Vaidyanathan, Nageswaran; Archibald, Philip; and Lohse, Mark, "Augmented Reality and Customer Experiences in Retail: A Case Study" (2020). AMCIS 2020 Proceedings. https://aisel.aisnet.org/amcis2020/strategic_uses_it/strategic_uses_it/18
11	128	5.3	Missing reference to Maguire (2001)	Missing reference	Add Maguire (2001) at the end of the sentence in section 5.3 as follows: … should be undertaken to incorporate usability requirements into the software development process. ***(Maguire, 2001) in his paper proposes a human-centered design process as summarized below***.

12	130	5.4	Reference to Siltanen (2015) was missed	Missing reference	Add (Siltanen, 2015) at the end of the sentence in section 5.4 …. involved in the design and development of the final solution to be implemented. ***Siltanen (2015) in her paper provides an overview of the human centered approaches of user involvement, co-design and co-creation as summarized below.***
13	137	6.1.2	As the consumers were unfamiliar with AR, the consumer sessions were started with an introduction to AR and what it can provide.	Wrong word used	As the ***users*** were unfamiliar with AR, the ***user*** sessions were started with an introduction to AR and what it can provide. Replace **consumers** with ***users*** as this involves the retailer and customer
14	138	6.1.2	Add Siltanen, 2015 as the para written was inspired from her paper	Missing reference	Add Siltanen (2015) at the end of the sentence Would you use this kind of solution to share designs? What sorts of products could be tested virtually? Any other comments? ***(Siltanen, 2015)*** .
15	163	6.4	Siltanen (2012)	Wrong reference	***Siltanen (2015)***
16	182	7.3.1	Missing reference	Missing reference	Add ***Poushneh (2018) in her paper discusses the implications to AR developers and this section references this paper to extend her findings to the cases studied*** after the sentence The implication for designers is to understand customer profiles and variables in wearing headwear to make sure it is comfortable.
17	201	References	Missing reference Hilken et al., (2018)	Missing reference	Add reference ***Hilken, T., Heller, J., Chylinski, M., Keeling, D.I., Mahr, D. and de Ruyter, K. (2018), "Making omnichannel an augmented reality: the current and future state of the art", Journal of Research in Interactive Marketing, Vol. 12 No. 4, pp. 509-523. https://doi.org/10.1108/JRIM-01-2018-0023*** Before Hilken, T., de Ruyter, K., Chylinski, M., Mahr, D., & Keeling, D. I. (2017). Augmenting the eye of the beholder: exploring the strategic potential of augmented reality to enhance online service experiences. Journal of the Academy of Marketing Science, 45(6), 884-905. doi:10.1007/s11747-017-0541-x
18	207	References	Missing reference Maguire (2001)	Missing reference	Add reference: ***Maguire, M., (2001). Methods to support human-centered design. International***

					Journal of Human-Computer Studies, (55), pp. 587–634. Before Mary Wolfinbarger, Mary C. Gilly (2003). eTailQ: dimensionalizing, measuring and predicting etail quality, Journal of Retailing 79, 183-198
19	214	References	Missing reference Siltanen (2015)	Missing reference	Add reference: ***Siltanen, S. (2015).*** **Developing augmented reality solutions through user involvement: Dissertation*.*** ***VTT Technical Research Centre of Finland. http://www.vtt.fi/inf/pdf/science/2015/S87.pdf*** Before Siltanen, S. (2012).˙Theory and applications of marker-based augmented reality¨. VTT Science 3. Espoo, Finland: VTT.
20	238	Appendix 12	Missing footnote for Business Insider	Missing footnote	Add footnote at bottom of page 238 https://www.businessinsider.com/ralph-lauren-interactive-mirrors-2015-11

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