The Investigation of Augmented Reality Marketing Tool Creation and Adaptability in Retail

Investigating The Impact of Augmented Reality Games on Customer Purchase Journey

Submitted to the OCAD University

in partial fulfillment of the requirements for the

degree of Master of Design (MDes) in Digital Futures.

By

Anas Raza

Adam Tindale | Alexis Morris

OCAD University

Toronto, ON Canada

April 2024

Abstract

This research paper investigates the potential integration of Augmented Reality (AR) into marketing strategies for small businesses, with a focus on how AR games can influence customer purchase journey. The research examines the concept of flow within AR experiences, emphasizing playfulness and perceived enjoyment as key factors in influencing consumer behaviour. The research work employs Research though Design (RtD) methodology to first create three prototype and use self-evaluation as a key method to evaluate the prototypes. This research paper demonstrates the prototype development and evaluates the prototype development process, investigating the practical application of AR for engaging retail customers. It also highlights the potential for AR to revolutionize retail environments. The research paper discusses the ethical implications of AR technology, including the discussion on the authority to augment spaces and the manipulation of consumer behavior. This research paper underscores the commercial potential and persuasive power of AR games in the retail sector, advocating for ethical practices in their deployment.

Keywords – Augmented Reality, Mixed Reality, Stimulus-organism-Response, Perceived Enjoyment, Gamification, Retail Environment, Environmental Psychology, Hedonic Purchases, Impulse Buying, AR Ownership, AR Ethics, Pavlovian Conditioning

Contents

Abstract 1

1. Introduction 5

  1.1 Motivation 5

  1.2 Overview 5

  1.3 Research Question 6

  1.4 Limitation 6

2. Literature Review 7

  2.1 Customer Purchase journey 7

  2.2 Consumer Purchase Journey and Store Environment 8

  2.3 Consumer Purchase Journey and Augmented Reality 9

  2.4 The Flow Concept 10

    2.4.1 Balance Between Challenges and Skills 10

    2.4.2 Perception of Control 10

    2.4.3 Interactivity 11

    2.4.4 Focus Attention or Concentration 11

    2.4.5 Perceived Playfulness 11

    2.4.6 Perceived Enjoyment 11

    2.4.7 Curiosity 12

    2.4.8 Perceived Usefulness 12

  2.5 Augmented Reality and Flow 13

  2.6 Gamification and Flow 15

3.1 Contextual Review 16

  3.2 Synthesis 19

4.1 Methodology 20
4.2 Design Rationale 20
4.3 Social Implications and Safeguards 21
5.1 Creation 23
5.2 The game 23
5.3 Process Work 24
5.3.1 Prototype 1 24
Conclusion/ Result/ Reflection 25
5.3.2 Prototype 2 26
Conclusion/ Result/ Reflection 27
5.3.3 Prototype 3 / Final Version 28
Designing UI 28
Multiplayer Approach 28
Gameplay Duration 29
Coin Positioning Strategy 29
Leaderboard 29
Concluding the gameplay 30
Testing 30
Conclusion 32
5.4 Game Development 34
5.4.1 Area Target 34
5.4.2 Multiplayer Networking 34
5.4.3 Scanning 34
5.4.4 Collectable Instantiation 35
6.1 Conclusion 36

6.2 Future Work 38
References 39
Appendix 51
Game Development 51
Initial Setup 51
Collectable Instantiation 53
Remote Procedural Call 54
Photon Networking 54
Synchronizing data 57
User Experience Limitation of multiplayer AR Games 57

Chapter 1

1. Introduction

1.1 Motivation

The inspiration for my thesis research and its prototype stemmed from my interest in mixed reality media, human psychology, and my growing interest in persuasive technology. My research took a decisive turn toward the persuasive nature of technology following an event in the summer of 2023. While strolling through my neighborhood one evening, I noticed a poster on a coffee shop window probing people to step inside the store and find a mythical creature in AR. Intrigued, I entered the shop, bought a coffee, and began searching for the creature using AR. The joy I felt upon discovering the creature compelled me to purchase another item so I could prolong my visit. This experience shifted my research focus toward exploring the impact of emotions on decision-making, specifically those evoked by technology and the persuasive nature of technology in influencing consumer purchasing behavior. The AR experience I have experienced in the coffee shop was a passive AR experience, the experience lacked interactivity. With my interest in gamification, I started to ponder the effects of gamified AR experiences on customer purchasing behaviour. This was the moment when I decided to shift my focus on investigating AR games as a persuasive marketing tool and its influence on customer purchase journey.

1.2 Overview

Digital technologies are increasingly innovating how marketing is done in the retail sector, with Augmented Reality (AR) standing out as a notable innovation. AR has become a pivotal interactive marketing tool, drawing increased research attention towards its marketing implications (Kumar, 2021). Alongside AR, gamification has also been recognized as an effective marketing strategy to engage consumers (Huotari, 2017). Despite this, there remains a notable gap in research that consolidates the findings from the field of augmented reality, gamification and their application in retail environments. This study speculates that the future direction of retail marketing and persuasion tactics will incorporate AR games into the retail landscape to attract customers. It begins by discussing the theoretical framework associated with Augmented Reality, gamification and their significance to the retail industry. Including the conceptual phenomenon of Flow state to later discuss its importance in the customer purchasing behaviors. The investigation employes Research through Design (RtD) methodology, by analyzing the feasibility of AR marketing tools through the prototype creation. The aim is to test whether we can build a prototype that uses both augmented reality (AR) and gamification as fundamental building blocks to build an experience for retail environments. Especially one that does not require a big team and accessible to small business owners.

The prototype aims to incorporate the game elements including challenge, skill, goal clarity and feedback system. The purpose of incorporating game elements into the prototype stem from the assumption that these are the antecedent of flow state, and they evoke subdimensions of flow like enjoyment, playfulness, curiosity, and time distortion which positively influence consumer purchase intention. The research leverages a knowledge synthesis approach to inform the design of the AR game. It then employs Research through Design (RtD) methodology for heuristic evaluation of the prototype creation aiming to analyze the accessibility and limitation of augmented reality marketing tools.

1.3 Research Question

1. How to build Augmented Reality games that can act as marketing tools to influence customer purchasing behaviours?
2. How Flow mediated by in-store Augmented Reality games can influence customer purchasing behaviours?
3. What are the sub-dimensions of Flow state that can influence customer purchase journey?

1.4 Limitation

While this study makes contributions to the development AR Marketing tools, it is important to note that there are several limitations. However, these limitations provide opportunities for future investigations. To begin with, the investigation of the primary question relied on a single AR software development kit however, several industry standard augmented reality development frameworks are available. This approach was useful keeping time constraint in mind, but it limited our evaluation of vast array of AR software development frameworks. The journal articles selected for the literature review discuss flow theory and its connection to games and the augmented reality medium. Missing out broader research material written on human emotions, store environments and purchasing decisions. Additionally, the exploration of secondary questions through empirical methods, such as user testing and surveys, presents another limitation.

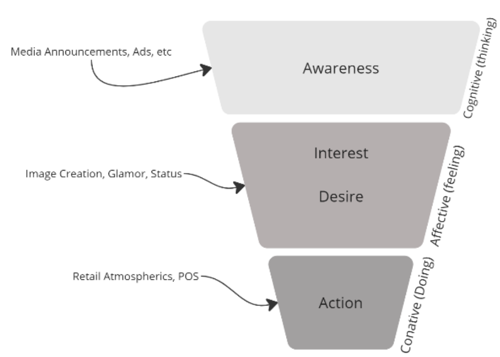
Chapter 2

2. Literature Review

A growing body of research discusses marketing-related issues surrounding Augmented Reality (AR) (e.g., Kumar, 2021; Rauschnabel, 2021; Smink et al., 2020). They define AR marketing as a strategic integration of AR experiences alone or in combination with other media or brand-related cues, to achieve overarching marketing goals by creating value for the brand, its stakeholders, and societies at large, while considering ethical implications (Rauschnabel, 2021). Previous research on AR marketing outlined the broader umbrella of literature on AR marketing, its related components, and effects on customer journey. However there remains a gap on how these experiences can be built and deployed for the retail environment. This section explores existing research on the consumer purchase journey, the concept of flow, the applications of Augmented Reality and gamification in retail, laying a foundational understanding that supports the premise that AR games can impact the consumer's purchase journey.

2.1 Customer Purchase journey

Before purchasing a product, customers typically go through a series of decisions making processes, known as customer purchase journey. The canonical model of this journey is the Awareness-Interest-Desire-Action (AIDA) “Purchase funnel” model (Kotler and Keller, 2012). Customers first need to become aware of the product, then their interest needs to be generated, they need to have the desire to consume and finally they take action to purchase the product. Marketing has always sought those



Canonical model of Awareness-Interest-Desire-Action(AIDA)

moments or touchpoints when customers are open to influence. If they have one goal, it is to reach the customer at the moment that most influences their decision (Court et.al, 2009). The AIDA model utilizes psychological dimension namely Cognitive, Affective and Conative to implement marketing strategies (Lavidge and Steiner, 1961). The cognitive dimension relates to information about the product, this is where slogans, announcements and media advertising play a part. The Affective dimension where customer is emotionally targeted to develop interest and desire, this is where consumer is targeted for image creation, status, glamor, and appeal. The Conative stage when the customer is stimulated to take actions, touch points including point of purchase advertising, retail store environment and deals announcement.

2.2 Consumer Purchase Journey and Store Environment

Retailers understand the importance of store environment as a tool for market differentiation and consumer satisfaction (Levy & Weitz, 1998). Retailing environments have been used to target specific customer emotional responses and exploit consumer characteristics to gain retailing success (Kotler, 1973). The seminal text of Mehrabian and Russel (1974) on environmental psychology demonstrates the impact of environment on shaping behaviour. The text provides a comprehensive way to understand how people react to their environments, focusing on three key components: Stimulus, Organism, and Response (S-O-R). The stimulus includes all the sensory variables in an environment, like light, sound, and temperature, as well as the information rate, which reflects the environment's level of complexity. The organism part of the model refers to the individual experiencing the environment. This part of the model also includes organism’s personal differences, such as emotional states and personality traits. These emotional states significantly influence how one interprets one’s surroundings. The final component, response, is about how individuals react to their environment based on their interpretation of the stimuli.

Mehrabian SOR model categorizes organism emotional response into three independent states: Pleasure-Displeasure explained as enjoyment and gratification, Arousal-Nonarousal which is denoted as the alertness of mental state, and Dominance-Submissiveness that relates to the control versus lack of control over one’s activities and surrounding (Russell & Pratt, 1980). The essence of Mehrabian and Russell's model is that our interaction with our surroundings is not just a straightforward reaction to physical stimuli but is significantly shaped by our internal processing, including our emotions, personality, and past experiences. This approach has been influential in various fields, helping to understand behaviors in settings like retail spaces, hospitals, work environments, and public areas (Vieira, 2013).

Building upon Mehrabian's Stimulus-Organism-Response framework and the principles of environmental psychology, we understand that the environment plays a pivotal role in influencing customer behavior and decision-making. The physical surroundings, along with individual emotional states and personality traits, interact to shape consumer responses. This foundational knowledge provides a critical backdrop as we pivot to the realm of augmented reality in retail spaces.

Augmented Reality technology supplements the physical world by augmenting it with virtual elements. It has the capability to enhance the visual, auditory, tactile, and olfactory perception of the user by superimposing digital content such as text, geolocation information, graphics, audios, and videos onto a live view of the physical objects and environments in real-time (Carmigniani et al., 2011; Fan et al., 2020; Sung, 2021). This potentially makes users experience more vivid, immersive, and interactive. Creating a store environment that is interactive and engaging. This added interactivity of the environment has shown to be profoundly influencing consumer behavior (Javornik, 2016). Boosting the number of visitors and extending the duration of their stay in the store (Emrich, 2022).

2.3 Consumer Purchase Journey and Augmented Reality

Along the consumer purchase journey, consumers are exposed to different touchpoints that determine their customer experience (Kietzmann et al., 2018). In the pre-purchase stage, consumers can be influenced by internal and external stimuli (Pine and Gilmore, 2011). Internal stimuli are individual emotional factors, such as arousal, pleasure, enjoyment and dominance or control (Vieira, 2013), while external stimuli are the environmental factors which can include design elements and technology (Jain and Bagdare, 2009). There is no doubt that technology has a strong impact on the retail landscape. Especially the interactive technologies like augmented and virtual reality, whose impact on the pre-purchase, purchase and post-purchase stages has been recently accelerating in academic studies. Indicating that AR can enhance consumer's utilitarian and hedonic purchase experience (Jones et al., 2006). Delivering a playful experience by increasing Perceived Playfulness which refers to the recreational element of the shopping experience (Rang et al., 2020). In addition to playfulness AR's ability to enhance product information (Hoffmann et al., 2022) by allowing consumers to see different views of the item with virtual try-on feature make them confident about their choice (Hilken et al., 2017; Romano et al., 2021).

The literature review highlights various findings on how consumers respond to the implementation of augmented reality (AR) in retail settings. Numerous scholars have explored the effects of AR, primarily employing two key approaches: the Technology Acceptance Model (TAM) and Flow Theory (Do et al., 2020; Du et al., 2022). While TAM sheds light on the factors that affect a consumer's readiness to adopt technology, Flow Theory focuses on the psychological aspects that drive the ongoing usage of technologies. It was noted in the literature review that antecedent to Flow are also the primary variables uses TAM model (Do et al., 2020; Brannon Barhorst et al., 202; Esteban-Millat et al., 2014; Davis & Davis, 1989; Sharafi et al., 2006). In the following section we aim to establish a connection between Flow and AR, and explore the literature to investigate flow effect on Customer Purchase Journey.

2.4 The Flow Concept

The concept of flow was introduced by Csikszentmihalyi in 1975. Since then, it has expanded and found applications across various fields of studies including games and Augmented Reality. Despite the continuing discussion around defining the concept of flow and identifying its key precursors, the variables commonly employed in research on flow include balance between challenges and skills; perception of control; focus attention or concentration; time distortion; interactivity; telepresence; learning; perceived playfulness; perceived enjoyment; curiosity; involvement; and perceived usefulness (Esteban-Millat et al., 2014). It should be noted that most research studies only feature a selection of variables from the above list.

2.4.1 Balance Between Challenges and Skills

With regard to flow experiences, challenges occur when an activity is tested, and skill refers to the individual perception of their personal ability to adequately meet or take advantages of the challenges (Esteban-Millat, 2014). Csikszentmihalyi regards skill and challenge as the most common flow predictor. Although studies in the literature point out the balance between skill and challenge is necessary for flow experience to occur (Guo and Poole, 2009), it is also observed that the balance between skill and challenge is not a condition for the flow occurrence (Ozkara et al., 2017). Regardless of contrary results on the balance between skill and challenge the research indicate that challenge and skill have a positive effect on the flow occurrence.

2.4.2 Perception of Control

Perceived control is a feeling of that arises when an individual perceives that they are in control of their own actions and their interactions with the environment in which they are operating (Koufaris, 2002). Csikszentmihalyi found that individuals tend to exhibit more positive behavior when they perceive that they have control over their environment. Similar to web browsing and games, in AR experiences a user has the ability to control not only their own actions but also their interactions with the environment.

Choosing to either advancing and exploring the content or by withdrawing from it. Perception of control over the action that user takes is not an inherent feature of augmented reality or any other digital medium, but it is a feature of particular application. For example, Pokémon GO created a perception of control through its interactivity where user felt in control of their action taken to play the game.

2.4.3 Interactivity

Interactivity refers to the dynamic process by which users engage with a system or media, and in turn, receive a response or feedback. It allow users to manipulate content and make choices that affect outcomes. it is an the one of the primary antecedents of flow experience. Hoffman suggests that the flow experience with technology is characterized by a seamless sequence of responses facilitated by machine interactivity (Hoffman et At., 2009). He further highlights that machine interactivity is intrinsically enjoyable, accompanied by a loss of self-consciousness.

2.4.4 Focus Attention or Concentration

Attention is considered a cognitive process in which an individual focuses their attention on a specific stimulus. For an individual to enter a flow state, they must devote all their attention to an environment generating stimuli (Esteban-Millat et al., 2014). It is one of the most widely used variables in flow studies. Several pieces of research suggest a relationship between flow experiences and focus attention or concentration (Csikszentmihalyi, 1975, 1990; Chen et al. 2000; Novak et al. 2000; Chou and Ting 2003).

2.4.5 Perceived Playfulness

The concept of perceived playfulness is used to determine an individual's intrinsic motivation to use a system for the purpose of entertainment (Chung & Tan, 2004; Chen et al., 2002). Playfulness has also been studied in the flow theory (Novak et al., 2000). In the flow literature the playfulness is not explicitly mentioned but it is implicit in the definition of flow. Which is described as an extremely enjoyable experience (Esteban-Millat et al., 2014).

2.4.6 Perceived Enjoyment

Refers to the overall pleasure and satisfaction derived from the user's interaction with a system or activity (Ghani & Deshpande, 1994). It is broader than playfulness, encompassing not only the fun aspect but also the fulfillment or contentment resulting from achieving goals, receiving rewards, or the aesthetic appreciation of the system. In the definition of flow proposed by Csikszentmihalyi, enjoyment is the important dimension in the flow experience. he specifies that the flow experience is extremely enjoyable.

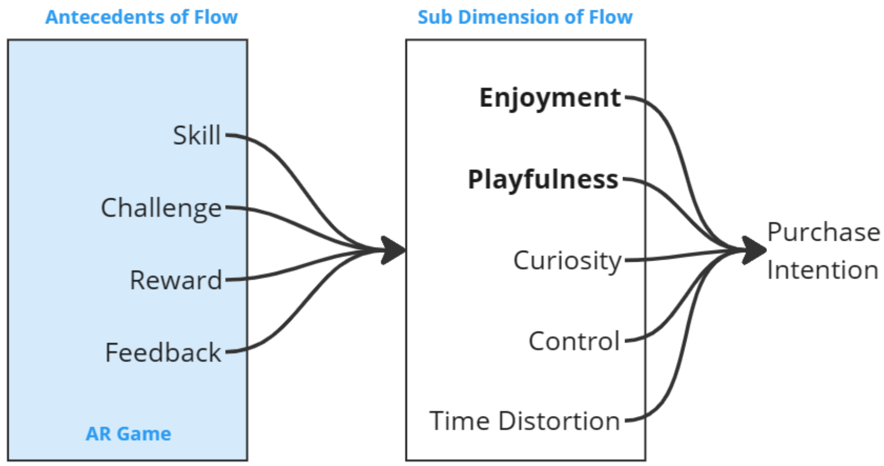
In the literature review of flow experience, it is observed that perceived enjoyment is one of the most frequent dimensions of the flow (Ozkara et al., 2017). It is not empirically clear in the literature review whether perceived enjoyment has a direct effect on the state of flow. But it is having been speculated that an enhanced state of flow provide by AR could influenced a greater sense of enjoyment (Brannon Barhorst et al., 2021).

2.4.7 Curiosity

Curiosity or exploratory behaviour is another mean of determining underlaying intrinsic motivation in an individual's action. According to Hoffman and Novak, curiosity is the desire to explore the options and opportunities in the environment available to the individual in which they are acting (Hoffman and Novak, 1996). It has also been linked to individuals' interest in interacting with technology (Charness & Boot, 2016). Literature review suggests that in the state of flow, individuals experiment with the medium in which they are acting, leading to the assumption that they are engaged in an exploratory behaviour (Agarwal and Karahanna 2000; Novak et al. 2000; Chung and Tan 2004; Sharafi et al. 2006).

2.4.8 Perceived Usefulness

Perceived usefulness has been described as the degree to which an individual believes that using a particular system improves their personal performance (Davis, 1989). The success of a system is depended on its ability to enable its users to easily carryout certain goal. In some flow studies perceived usefulness is associated with extrinsic motivation creating a perception that the environment or system is useful (Chung and Tan, 2004; Koufaris, 2002). Although perceived usefulness is not the most studied precursor to flow state. It has been the most prominent variable in the Technology Acceptance Model, and a key concept in the study of adoption of innovation. This association make it relevant when curiosity is studies as a precursor to flow state.



(Flow, its antecedents and subdimensions, Ozkara et al., 2017)

2.5 Augmented Reality and Flow

Csikszentimihalyi (1975, p.36) introduced the phenomenon of flow as a 'holistic sensation that people feel when they act with total involvement'. When experiencing the notion of flow individuals often enter a state where they completely switch off to the outside world and immerse themselves in the task at hand. Csikszentimihalyi illustrates how flow exists during games such as chess, rock climbing and dancing.

In the context of Augmented Reality, flow state has been associated with interactivity, media vividness and novelty (Barhorst et al., 2021), leading to enjoyment and focused attention. AR technology through its media vividness and novelty is considered one of the most interactive types of technology. This interactivity can be considered from two complementary positions, the inherent feature of the technology and the user's perception of the particular AR application. Empirical research (Yim et al., 2017) highlighted that compared to media ads consumer categories AR technology as the most interactive technology requiring a high level of user participation. Given that the interactivity involved with AR involves manipulating both the physical and virtual world, such user participation and control will lead to an absorbing and focused attention. Research indicates that interactivity and focused attention positively influence the state of flow (Barhorst et al., 2021).

In addition to interactivity, Vividness is considered another driver of flow in AR. Vividness is defined as 'the ability of a technology to produce a sensorially rich mediated environment' (Steuer, 1992). This concept involves merging the sensory perception of tangible objects with the imaginative creation of intangible elements in a person's mind, forming a distinct and comprehensive representation of a product or experience (Lee, 2004). AR ability to render three dimensional and spatially distributed information overlaying on the physical product makes it an ideal medium to deploy vivid information. With regards to the vivid information, it creates the aforementioned, perception of usefulness. This enhances the perception of information quality and cognitive processing by offering a rich and immersive environment. This detailed combination improves engagement and immersion, leading to a deeper flow experience (Hilken et al., 2018).

The novelty of AR is another major factor that has an influence on driving the state of flow. AR experiences offer novelty in two senses. The newness of the technology and the augmented combination of the real and virtual world. McLean and Wilson (2019) describe how blending the real world with the virtual world creates an experience that is consistently unique. As a result, whenever someone uses augmented reality, they are likely to experience novel stimuli, given the extensive possibilities for interplay between the virtual and real world's which fuel curiosity to explore the environment. In the literature review, it was noted that curiosity positively influences the state of flow.

Augmented Reality (AR) has the unique capacity to create a flow experience due to its high level of interactivity, vividness and novelty, which directly align with the key components identified by Csikszentmihalyi and subsequent researchers as essential for inducing flow. Initialization and usage of all AR experiences demands active participation from users. It does not merely present information or provide passive entertainment but instead require users to interact with digital content superimposed onto the physical environment. Even in passive AR experiences, where a 3D model is situated within the environment to provide information, users are required to either move around the object or, at the very least, manipulate the object via touch controls. This level of engagement is significantly higher than the engagement required by traditional screen-based experiences where interaction may be limited to simple input. For example, in a conventional screen-based experience, users might simply click on a video to play it or scroll through a webpage to read information. There is no need for body movement or spatial interaction; the engagement is primarily through clicks, taps, or keystrokes. This makes AR not just a tool for enhancing digital experience, but an important medium for achieving the state of engagement, immersion, curiosity that defines flow.

2.6 Gamification and Flow

Gamification is the use of game elements such as levels, points, badges and other for non-game context (Deterding et al., 2011). The elements of gamification techniques are used to enhance user experience in different area, such as education, marketing, healthcare and other (Dreimane, 2018). Studies indicate that gamification can affect different types of positive psychological experience and one of the main psychological experiences that is influenced by gamification is flow experience (Oliveira et al., 2021). In the recent years one of the main goals of gamification is to keep user fully engage and immersed in the process of activity. And game elements like skill, challenge, rewards, and control are the main ingredients to mediate the state of flow. Games and most gamified experiences are designed to match the difficulty level with the player's skill level, creating a challenge that is neither too hard nor too easy. The balance between skill and challenge is a crucial driver to create the state of flow. In addition to balance between skill and challenge, games or gamified experiences create a situation where players feel that they have control over their actions (Risso & Paesano, 2021), players frequently report losing the track of time (Wood et al., 2007), and engrossed in gameplay that they lose awareness of themselves (Swinkels et al., 2021). These dimensions of gameplay make gamified experiences ideal to induces the state of flow.

Chapter 3

This section contextualizes augmented reality games for retail stores by highlighting literature that support the idea and provide some examples of AR experiences that are used in the retail sphere.

3.1 Contextual Review

The retail sector is undergoing rapid transformation, primarily due to the rise of e-commerce, which presents challenges for traditional brick-and-mortar stores. However, many consumers continue to appreciate the in-store shopping experience. This preference extends beyond just the utilitarian aspects of purchasing, as they seek hedonic experiences as well (Hirschman and Holbrook, 1982). One of the key motivators for shopping is the value gained from the overall purchasing experience. There are two types of shopping motivation, namely hedonic and utilitarian (Senecal, 2002). The utilitarian shopping is goal oriented where customer's primary objective is to complete the shopping job. On the other hand, the hedonic shopping motivations are related to the goal of seeking hedonic satisfaction, such as imagination and sensory stimulation (Babin et al., 1994). The hedonic experience of shopping refers to the pleasure and enjoyment derived from the activity. This type of shopping is characterized by exploration, entertainment, and emotional satisfaction. It's the sensory pleasure, excitement, and fun that consumers seek in the shopping environment (Tarka et al., 2023), whether it's through browsing, discovering new products, or the ambiance of the shopping space (Kotler, 1973). Hedonic shoppers are motivated by the desire for leisure, escapism, aesthetic pleasure, and social interaction. Numerous research works emphasize the hedonic aspects that consumers often pursue in their shopping experiences. (Tarka and Babaev, 2022). Since customers value enjoyment factor of the experience, retailers can enhance their in-store experience by combining both hedonic and utilitarian values when integrating digital elements.

The retail industry has been employing various techniques to enhance their in-store experience for customers. Some of these techniques include store layout and design, in-store events, customer services, and integrating interactive technologies (Gauri et al., 2021). Recently there has been an increasing interest in integrating interactive technologies in the retail sector (Wang et al., 2023; Briggs, 2023). Technologies like augmented reality (Wang et al., 2023), interactive displays (Briggs, 2023) and gamified brand story telling (Tseng et al., 2021).

Authors like Kai Huotari and Juho Hamari in their research on gamification discuss how game-like elements can be implemented in non-game settings like retail to enhance the experience. Their research finding shows that gamified store experiences linger between hedonic and utilitarian benefits. They define gamified experiences as activities that use game design elements in non-game context. For example, applying challenge and rewards system in the activity. Furthermore, research studies indicate the potential outcome of gamified experiences as enjoyment which makes these services hedonic (Deterding et al., 2018). This potential makes gamification an interesting option for customer engagement, retention and purchasing attitudes.

The Technology Acceptance Model (TAM) (Davis, 1989) that provide a useful tool to measure and predict the adoption of new technologies and why user accepts (or reject) new technologies (Rese et al., 2014). TAM uses several measures including Perceived Usefulness and Perceived Enjoyment. TAM and flow theory both highlights the abstract experience of perceived enjoyment. Which refers to the extent to which the use of the system is perceived as enjoyable on its own (Davis, 1989). In the context of games or game like systems the enjoyment of using the system has been demonstrated to be a primary factor affecting the use intention. Therefore, there is reason to assume that similarly to games, enjoyment will positively influence the use intentions of a gamified service (Wang & Scheepers, 2012). In addition to enjoyment, the gamified systems are often used to make the system playful. Furthermore, it is expected that if the service is perceived playful and enjoyable the attitude towards the system becomes positive (Hamari & Koivisto, 2015). The interaction with the gamified system may perceived playful and enjoyable.

In the context of Augmented Reality, the principle of gamification gains an innovative dimension. AR's capability to blend digital elements with the real world not only enhances the visual and auditory perceptions, but it introduces user's intention to explore the physical environment (Lin et al., 2022). Several studies (Hedley et al., 2002; Deloitte, 2022; Lin et al., 2022) demonstrate how AR, by adding layers of information, interactivity, and gamification, can motivate people to explore and engage with their physical surroundings more deeply. Encouraging them to spend more time in the environment. Several studied suggest a correlation between time spend and purchase intention. However, the views on the relationship between the time and increased purchase intentions are very diverse. Studies support the notion that increased time spend in a store positively influence customer buying intentions (Mihić et al., 2018; Martínez & Casielles, 2018). Some studies suggest a curvilinear relationship, where excessive time can lead to decision fatigue and decrease purchase intention (Sun et al., 2023).

Furthermore, the inherent interactivity of the AR (Barhorst et al., 2021) and the built interactive by design of the AR games can put AR games in a unique position within retail industry. In the literature review it was established that interactivity has a positive influence on the enjoyment factor of the experience. By incorporating elements like treasure hunts and scavenger hunts, AR games can gamify the shopping experience, adding fun, excitement, and a sense of achievement into the process. This enjoyable engagement not only enhances brand perception (Högberg, 2019) but also motivates exploration (Hedley et al., 2002), potentially leading to increased purchase intentions.

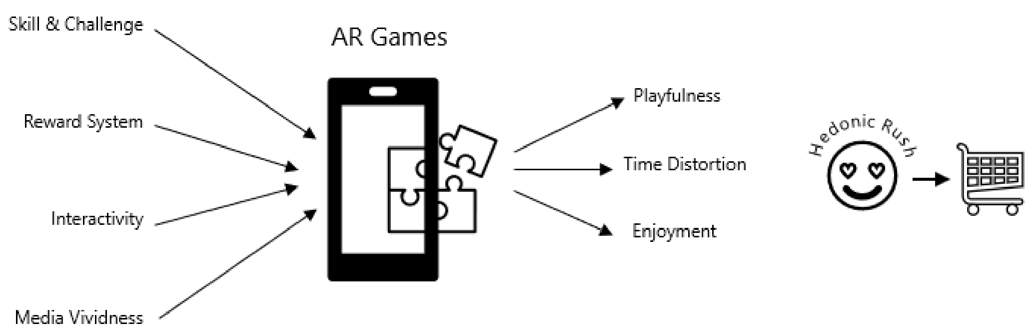
Recently there has been a growing interest in deploying AR games within the retail environment to boost foot traffic and enhance purchase intentions. Niantic's "Sponsorship Program" offers businesses the opportunity to participate, making their locations visible on the Pokémon game map. This visibility encourages players to visit the stores for a unique Pokémon gameplay experience tied to the specific location. Besides the Sponsorship Program, Niantic introduced an Augmented Reality Development Kit (ARDK) in 2022, designed to empower developers to craft location-based experiences. This ARDK opens up numerous possibilities for the retail industry to develop gamified in-store experiences aimed at boosting sales by influencing customers through AR games.

Several studies empirically test the effect of location-based AR games, and they found a positive relationship between game engagement and sale (Chen, 2016; Frith, 2017; Keogh, 2017; Pamuru et. al, 2021). A large number of research has concentrated on aspects such as mobility, novelty, gamification, and nostalgia as a key factor of AR games in the retail environment. A research gap exists in studies directly investigating the influence of enjoyment and playfulness of AR experiences on the customer purchase journey. Wine company 19 Crimes uses an AR game as their marketing gateway. The wine bottle label nudges customer to scan the bottle to bring the characters to life who tell the stories of the crime, motivating customers to “collect” (buy) all 19 bottles of wine (19crimes, 2024). In 2020, Pepsi launched AR promotion starring four famous soccer stars. The promotion limited edition Pepsi cans that came with QR codes. When scanned, these codes brought digital versions of the soccer players to life on users’ smartphones. People could then play a virtual soccer game, doing kick-ups with the players, and even share their scores on Instagram. This AR game was part of Pepsi's ‘Pepsi, For the Love of It’ campaign. It was designed to drive engagement and brand recognition. However, there is no public data available to show the success of the promotion campaign. While AR games have made their mark in the broader marketing sphere, their adoption has primarily been by large corporations equipped with substantial budgets and dedicated teams.

3.2 Synthesis

The literature review highlights concept of flow state and provide a framework for understanding and defining engagement. It was also established that flow state is not a unidimensional state but a multidimensional state with several sub dimensional psychophysiological states, for example playfulness, enjoyment, perception of control, curiosity etc. The review provides a significant body of research supporting the notion that games with their fundamental building blocks including skill, challenge, reward, and feedback play an antecedent role in inducing flow. Similarly, AR through its interactivity, media vividness and novelty is praised for providing antecedent of flow sub dimensions including, playfulness and enjoyment. Furthermore, the literature review synthesizes the elements of gaming with AR to point out that AR games can emerge as a potent strategy for amplifying customer engagement. The AR games can enrich the retail experience by integrating game mechanics (skill, reward, challenge) along with the vividness and interactivity characteristic of AR. This combination can not only enhance the hedonic aspects of the shopping experience it can provide utilitarian benefits including product information and store navigation. Opening up opportunities for the retail sector to leverage AR games to engage consumers more deeply, encouraging them to discover more within the store and increase their in-store time spent.

Based on the literature review the research work aims to build a prototype that is informed by the synthesis of theoretical framework. The aim is to assess whether we can build a prototype that uses both AR and gamification as fundamental building blocks to build an experience for retail environments. Especially one that does not require a big team and accessible to small businesses owners.



A diagram showing antecedent of flow and sub dimension of flow and their relationship with customer purchasing behaviour.

Chapter 4

4.1 Methodology

This research employed Research through Design (RtD) to inform the prototype design. "Research through design" is the closest to the actual design practice, recasting the design aspect of creation as research. Designer/researchers who use RtD actually create new products, experimenting with new materials, processes, etc. (Godin & Zahedi, 2014). In 2006 Wolfgang Jonas proposed a macro model of knowing in design which refers to how designer transition their focus from 'true' to 'real'. In the model they set three steps namely analysis, projection and synthesis. Analysis refers to how things are currently (true). Projection refers to how things could be for example idealizing through artifact creation (the ideal), and synthesis, which concerns with how things will be (the real).

The Marco Model can be applied to the iterative process of prototype creation by providing a structured framework that guides the iterative process.

Analysis: This phase focuses on understanding the current situation of the prototype. It involves analyzing the capabilities and bugs in order to comprehending the situation as a whole. This step is crucial for informing subsequent design decisions.

Projection: Here, the focus shifts towards envisioning future possibilities for the prototype. Scenarios are developed to explore different directions the prototype could take, leading to a clearer understanding of desired outcomes.

Synthesis: In this phase, the insights gained from analysis and projection were synthesized to plan solutions for the prototype aiming to address the identified bugs and achieve the desired prototype form.

4.2 Design Rationale

The design of the game prioritizes user experience above all. The strategic positioning and proximity of game elements was drawn from studies underscoring the critical role of spatial and semantic coherence in arranging content for mixed and augmented reality settings. Research by Cheng et al. (2021), Ellenberg et al. (2023), and Lee et al. (2021) suggests that 3D content is more effectively presented on horizontal surfaces in mixed and augmented reality settings, whereas 2D information is better suited to vertical surfaces. Drawing on these findings, the game strategically positions 2D promotional banners on vertical surfaces, ensuring that the content is spatially coherent and fosters a sense of Perceived Unity, as discussed by Ellenberg et al. (2023).

In addition to augmented content placement the game UI take advantage of the multiplayer aspect of the game by highlighting the number of co-located online players in the app interface. The research finding taking Pokémon Go as case study suggest increased engagement and increased enjoyment of the gameplay when players are in a co-location social game. However, there are several dynamic elements that take part in the studying the engagement parameter of co-location games including competitiveness, social interaction, attractiveness, enjoyment factor and more (Hamari et al., 2019; Laato et al., 2022; Paasovaara et al., 2017; Qin, 2021; Quinn, 2016; Vella et al., 2019). Further research is required to fully investigate how player respond to the UI elements that emphasise multiplayer co-located element of the AR games.

In addition to the personal app interface, the game incorporates a leaderboard or scoreboard feature. This leaderboard is designed to display the game's status in real-time, such as the number of users currently online, their coin count, and the remaining time for the current game session. The purpose of the leaderboard is to enhance competitiveness among players and to serve as a visual indicator to potential future players who are co-located in the game area. Some studies suggest the negative effect of leaderboard on low-ranking participants (Ipeirotis et al., 2015). However, a majority of prior research shows an increased user participation when leaderboards are applied (Halan et al., 2010; Matin et al., 2020; Park & Kim, 2021; Tang & Zhang, 2018). Therefore, this prototype utilizes leaderboards to encourage participations.

4.3 Social Implications and Safeguards

AR gaming in retail holds transformative potential for marketing and persuasion, with significant implications for consumer behavior. However, it's essential to address the ethical challenges this technology may pose and provide safeguards that can help mitigate these challenges.

At the heart of AR technology is the need to collect and analyze spatial data, which involves constructing a 3D map of the environment using cameras and sensors. This data includes the location, dimensions, and relationships of objects and their interactions with individuals. While this data collection might seem benign, it can lead to exploitative practices if misused for profit-driven motives. For example, companies could manipulate consumers by subtly altering their psychological states through digital cues integrated into their surroundings, thereby compromising individual autonomy and cognitive freedom.

The use of AR also raises broader social and legal issues. The launch of Pokémon Go illustrates this point vividly. Its widespread popularity led to unexpected gatherings in public spaces, sometimes causing disturbances like noise and litter. These games transform private homes and public spaces into virtual playgrounds, often without the consent of the residents or consideration of existing social norms. This has led to conflicts between digital content and physical property laws, as seen when the Auschwitz Memorial Museum had to request the removal of the game from their grounds.

Legal implications are equally crucial. Issues such as user tracking, injuries due to inattention, and trespassing highlight the need for clear regulations regarding AR's interaction with real-world spaces. For instance, the extent to which property owners can control AR activities on their property remains a significant question (Neely, 2019). The creation and placement of persistent digital images in real-world environments, which can have both playful and harmful implications. For instance, AR can be misused to target and harass individuals or groups by marking their homes or gathering places with invisible digital graffiti. This can amplify harmful behaviors by bad actors using platforms like Facebook's AR technologies.

Moreover, incidents like Snap Inc.'s 2017 campaign, which involved placing AR art in public spaces without official permissions, prompt critical discussions about who has the right to augment public spaces and under what conditions.

Given these considerations, it is imperative to establish robust safeguards that prioritize ethical standards and respect for individual rights in the deployment and development of AR technologies. This involves crafting policies that protect personal data, prevent manipulative practices, and ensure that the integration of AR into daily life enhances rather than diminishes public good. The safeguards involve multiple layers of policy, technology, and community engagement to ensure privacy, fairness, and transparency. For example, clearly communicate to users how their data will be used, who will have access to it, and under what circumstances. Allow users to access, correct, and delete their data. Provide options for users to opt-out of data collection. Conduct ethical impact assessments during the development phase to identify potential harms and mitigate them before products are released. Work with industry groups to develop standards and best practices for ethical development. Engage with a broad range of stakeholders, including civil society, technologists, ethicists, and users, to understand diverse perspectives.

Chapter 5

5.1 Creation

The prototype is built for potential use in the retail environment. The creation is inspired by the basic scavenger hunt gameplay. It leverages AR marketing strategies including 3D product visualization, product navigation and most importantly location-based gamified experience. The prototype demonstrate how we can deliver a unique and interactive experience by engaging players in a gamified experience.

The prototype is built using Unity 3D environment. The AR capabilities are integrated using Vuforia Augmented Reality SDK and the networking is supported by Photon Engine SDK called PhotonPUN2.

5.2 The game

The game is a location-based and multiplayer coin collection AR experience designed for mobile phone devices. It uses Vuforia Area Target capabilities to place game object on a precise location. Vuforia Area Target create a 3D scan of the environment to make sense of the surroundings when placing 3D object. Using this technique the game places virtual coins in the environment. The coin placement is strategic to its juxtaposition with promotional sales banner that are designed for product promotional purposes. This strategy is used with the intention that player will notice the promotional banner out of curiosity that the banner may have information regarding gameplay. The assumption is that the placement of the promotional content closer to game object makes the promotional content more noticeable which otherwise goes unnoticed.

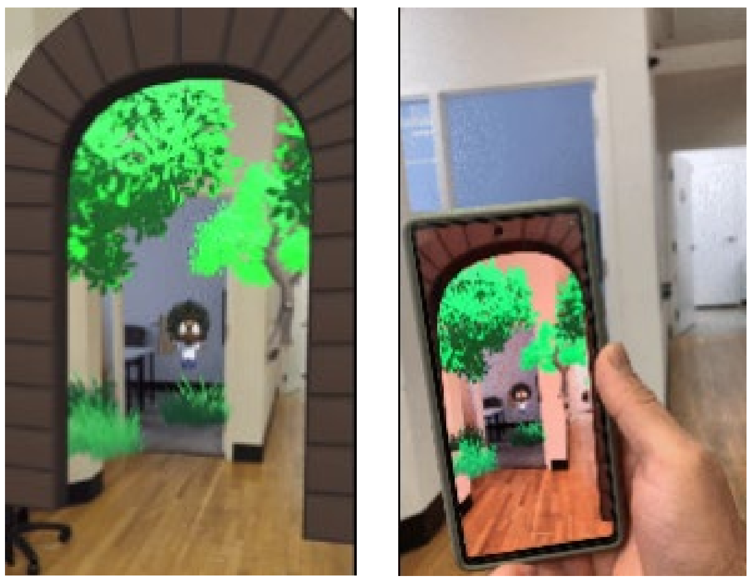
To find the coins, players must physically navigate their environment and tap on virtual coins to collect them. Each game session has a limited number of coins. Each player can see how many coins has been collected and how many coins are left to be collected. As part of the multiplayer aspect, players can also see the count of other online players in real-time. The game concludes when all coins have been collected. At the end of the game, the winner is announced, and they can utilize the accumulated coins to claim a gift pack.

5.3 Process Work

This section provides a summary of process work key prototype iterations and reflect on the insights that were gained during the process work.

5.3.1 Prototype 1

The first protype was using AR portal which is a virtual design object used a doorway to enter an immersive environment in augmented reality experiences. the idea was to use AR portal as a virtual door on the physical door of a retail stores to provide a primer that augmentation start ahead. The concept originates from the observation that, within AR experiences, there lacks a perceptual entry point or an initial cue that signals the commencement of the augmented reality experience. Incorporating such a cue at the entrance of a retail store could stimulate users' curiosity, inviting them to enter the store to explore



Screenshot of prototype 1 showing AR portal and its alignment to the physical door

further. Building on the findings from the literature review, which identifies curiosity as a dimension of flow, this approach could significantly enhance customer engagement by leveraging natural human curiosity as a driving force for exploration within the retail environment. The novelty of AR technology was another element that was considered to attract customers. In the literature review Technology Acceptance Model highlighted novelty as a vital component of technology, influencing users to engage and use the technology.

The initial idea was to offer this experience without necessitating users to install any application on their smartphones. This consideration emerged from examining research findings that identified the app installation process as a potential barrier for users when attempting new experiences. The idea was to bypass the app installation requirement by offering a WebAR experience. However, after exploration of WebAR capabilities, it was determined that AR experiences delivered through web browsers currently lack the sophistication needed for comprehensive AR functionalities. For instance, they fall short in supporting crucial elements like the Occlusion Shader component, which is essential for constructing an AR portal. Additionally, it was planned to add networking features to later versions which is not accessible in the WebAR libraries and the available WebAR libraries have a steep learning curve.

As a result, I opted for Unity 3D in conjunction with the Vuforia library. Vuforia offers industry-standard AR features, such as Plane Detection for identifying surfaces to place 3D objects, ImageTarget to trigger AR experiences based on specific images or patterns, and AreaTarget capabilities. AreaTarget involves scanning an area with LiDAR scanners to generate a map, which is then utilized within Unity 3D to create immersive AR experiences. for the first time protype I have used the plane detection feature to place the virtual objects.

Conclusion/ Result/ Reflection

There were several insights emerged from developing the fist prototype, leading to key adjustments for my second prototype. A notable insight was the use of plane detection to position the AR portal over a physical door, serving as a visual prompt to mark the beginning of the AR experience. However, the process of aligning the AR portal with the physical door proved to be less intuitive than anticipated. Users had to accurately adjust the AR portal to ensure it seamlessly integrated with the physical door, involving several steps such as plane detection, and the sizing and resizing of the AR portal. These adjustments were also influenced by the distance between the user’s device and desired placement surface, lighting and the texture of the floor plane. Given the complexity and time required for this setup, it became clear that this method was impractical for a retail setting. Even for those familiar with AR technology, the process demanded excessive user involvement, making it unsuitable for a smooth and accessible user experience. An alternative to the manual positioning of 3D objects involves utilizing live 3D surface detection capabilities found in AR libraries. However, these functionalities are not accessible through the Vuforia library, and existing software development kits do not offer these advanced features. High-level augmented reality devices, such as Apple Vision Pro and Oculus Quest, prevent this limitation by employing specialized depth cameras and sensors to accurately interpret the environment and place 3D objects within it. This advanced capability is absent in smartphone devices that rely on RGB cameras. For instance, Pokémon Go uses GPS technology to anchor 3D content in the real world. While GPS technology facilitates automatic placement, its accuracy ranges from 1 to 3 meters, leading to potential content displacement of up to 1 to 3 meters. Including GPS signal distortion in the indoor environment.

5.3.2 Prototype 2

Drawing on insights from the first prototype, the second iteration progresses from using plane detection as the 3D content anchoring technique to Vuforia AreaTarget techniques. AreaTarget uses depth camera to create a 3D map of the area. This can be done using professional 3D scanning cameras or iPhone devices equipped with LiDAR sensor. I used iPad Pro to scan the area. The scanned area map can be imported into the Unity3D project and used as an 3D anchoring reference to create an AR experience for the scanned area.

Moving ahead from solely using an AR portal, the second iteration incorporates game elements into the experience. This approach to integrating game elements into AR experiences is inspired by literature reviews indicating that gamified services can achieve deeper customer engagement. In the literature review, I have highlighted that AR experiences through its interactivity (Barhorst et al., 2021) and perceived playfulness (Rang et al., 2020) can act as external stimulus to engage customers and consequently influence their purchasing decisions. The second iteration tries to create a playful experience by employing the interactivity of the AR medium. The playful experience is created using coin collection as the core game mechanics. Users are motivated to physically move and navigate the space through their device to locate and gather coins. This collection process is made interactive through touch-based interactions.

The second iteration primarily utilizes coin collection as a measure of user engagement, implying that the quantity of coins collected serves as an indicator of sustained user interest in the gameplay. suggesting that the users likely found the gameplay compelling. Keeping the concept of flow as the guiding principle that put skill, challenge and feedback as antecedent of flow state. To achieve such a state a user must find the balance between the skill required to play the game and challenge that they face. Focusing on this strategy I placed the coins that are easily discoverable. However, in retrospect, this approach may have overly simplified the gameplay, lacking sufficient challenge to engage players meaningfully.

Conclusion/ Result/ Reflection

During the development of the second iteration, I acquired numerous insights, particularly about the capabilities of AR technology and its potential for integration into retail environments. The primary challenge hindering the adoption of AR technology is its space recognition capability. Although the AreaTarget feature offers more sophistication than the plane detection techniques used in the first iteration, it still struggles with the spontaneous recognition of surroundings. When the application is started it requires some time to initialize and the recognize the environment. Since the prototype was developed to explore the space, mobility is the key component. Which means the AR game must continuously calibrate to accurately determine the device's location within the space and correctly place 3D elements in the space to create a seamless game experience. The displacement of 3D game objects in an outdoor geo spatial game do not drastically affect the gameplay. For example, the displacement of Pokémon Go creatures within 1-to-2-meter diameter had not disrupted the gameplay. However, a displacement of game objects, such as exceeding half a meter, in an indoor AR game, can severely disrupt the entire gaming experience. This accuracy relies heavily on the AR system's capability to identify the environment accurately. In this prototype, the positioning accuracy of the AR system hinges on the resemblance of the physical environment with its scanned 3D map that was fed to the AR system during development. Minor changes to the physical environment after the scan may not affect the area recognition ability but major changes will result in the inability to recognise the area. For instance, slight adjustments like moving a chair may not disrupt the AR application's ability to recognize the area and launch the experience, but extensive rearrangements can interrupt the game experience.

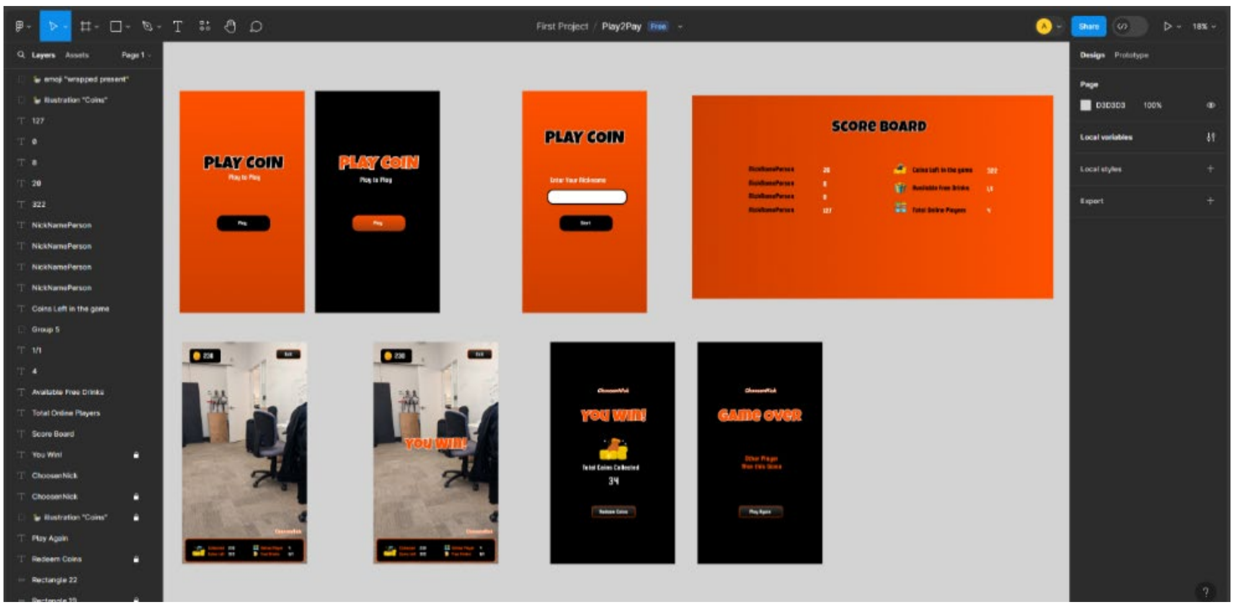
Another notable challenge with using AreaTarget is its dependence on the texture or clutter within the physical space. More objects in the space mean a richer texture on the 3D map, leading to better space recognition. This insight became evident during a test run of the app for the Digital Future Open Show. I scanned the graduate gallery on the first floor of 205 Richmond St. At the time of scanning, the gallery was relatively empty, devoid of furniture or project setup. This lack of rich texture failed to meet the AreaTarget's requirements for effective space recognition.

During the development period the area that I had initially scanned did not change drastically but minor rearrangement of the room furniture did affect the accuracy of 3D content placement. In the retail store environment where the layout of the store might remain unchanged, the placement of new products on the shelves can add difficulty to recognize the space. One potential remedy is to periodically rescan the area to account for these changes, but this approach demands additional training and resources, which retailers may be reluctant to invest in. This issue stands out as a significant barrier to the widespread integration of AR technology in retail environments.

5.3.3 Prototype 3 / Final Version

Designing UI

Before diving into the development phase, a user interface (UI) design was carefully crafted in Figma to establish a unified design framework. This iteration of the prototype followed a strict design guideline, ensuring a seamless and coherent user interface experience.



Screen screenshot of user interface design created in Figma.

Multiplayer Approach

This version of the prototype incorporated multiuser approach to facilitate a collaborative AR experience. the idea was to create a collaborative yet competitive gameplay inline with the game studies literature that support the thesis that competitive game play encourages participation and engagement. Another aspect of multiuser experience is that it creates a honey pot effect which refers to the influence of players on non-players to participate in the gameplay. Aligning with research (Mehta et al., 2013) indicating that a moderate level of crowding could potentially enrich the shopping experience by contributing to a lively atmosphere. Multiuser gameplay is one of many techniques that can be used to increase the foot traffic because it adds collaboration, competitiveness, and social element in the game. The prototype creation and the addition of multiuser aspect was to verify if this type of experience can be build using AR technologies.

Gameplay Duration

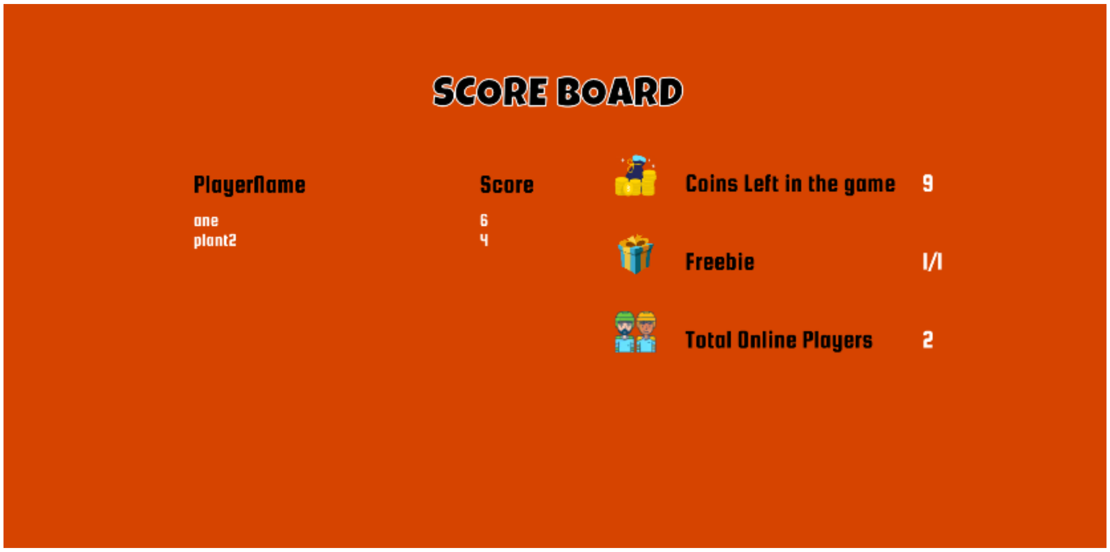
The design of the prototype prioritized user freedom as a key element. Players have the flexibility to join or exit the game at any stage. This prototype introduces a novel category of games that require further exploration, including player time commitment, and the optimal duration of gameplay. Visitor (potential players) may not want to commit for a longer gameplay duration and creates a gameplay that is not longer than 5 minutes. The time duration of the gameplay is also dependent on few other variables including store size, number of coins in the store, their visibility and total number of other online players.

Coin Positioning Strategy

The layout of the store and placement of the item in the retail store influence purchase intention (Bhadury et al., 2016). Marketer and retailers have been using this strategy to enhance sales and customer engagement. However, the study of placement of virtual object in the augmented space and their influence on customer behaviour is a new paradigm. The concept introduced by Pokémon Go, which uses virtual game objects as a lure to attract customers into retail stores, has opened new avenues for research to investigate how the placement of these virtual objects' influences purchasing intentions. During the development of the second iteration of the prototype, I realized that while Pokémon characters successfully increased foot traffic to the store, they did not guide players to any specific section of the store. In thinking about store navigation and guiding the players to the specific section the prototype 3 strategically position coins in the game environment.

Leaderboard

While working on the third iteration, I recognized that although players can view the total number of participants and the remaining coins, non-players, who are not playing the game, should be provided with a visual prompt that can encourage participation in the game. Borrowing from the conventional video game component I have developed leaderboard which shows the names of all players, their scores, remaining coins and collectable freebies. The leaderboard or scoreboard is intended to be display on a screen that is co-located where the game is being played.



Screenshot of leaderboard showing total number of players, remaining coins, players names and score of all online players.

Concluding the gameplay

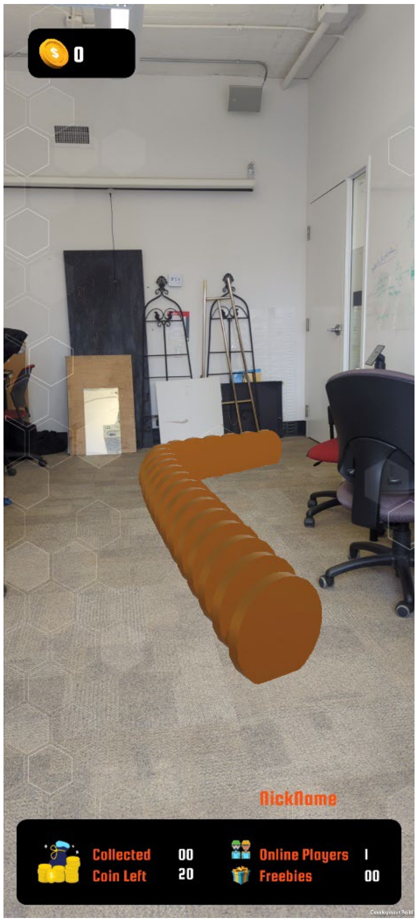
The final prototype continuously keeps track of player scores to announce the winner when the last coin is collected. The wining player is then prompted to redeem these scores to win a gift or get a coupon. While the winner is prompted to claim their prize, other players are prompted to play it again. The present version of the prototype does not accommodate tie situations or scenarios involving a single player. However, future work may explore strategies to address these circumstances.

Testing

The game is playable in the same area that was scanned and fed to the Vuforia AreaTarget system during development. During the prototype iteration phase, I scanned multiple areas for testing, with a significant portion of testing conducted in an 11x17 ft room situated on the university campus. The room was characterized by a considerable amount of clutter and provided an ideal environment for the Vuforia AreaTarget system to generate a detailed texture map.

While testing, I discovered that the rapid movement of phone device has an impact on the accuracy of gameobject positioning. The Vuforia AreaTarget system faced difficulties calibrating the positions of game objects when device was moved rapidy. This issue was more pronounced in less cluttered environments and minimal in areas with more clutter.

Regarding the speed of coin colletion the latecy of the network significantly impacted how the coin count is calculated. In the current approach coin count is done remotley in the cloud. When a coin is collected



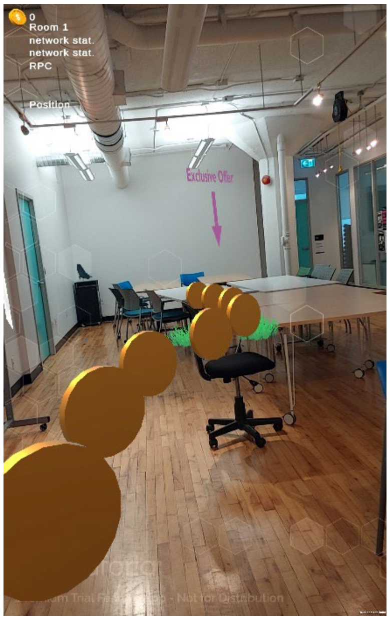
Spline based coin distribution towards a targeted location.

the game app send a messgae to server that the particular player has collected a coin but if the palyer’s tap frequecny is too fast, for example, If there is less than one second of delay between each tap, network latency affects the player's total coin count. To resolve this issue, I have spaced the coins further apart and disabled the device's touch input for one second after a coin is collected. This adjustment has significantly enhanced the gaming experience.

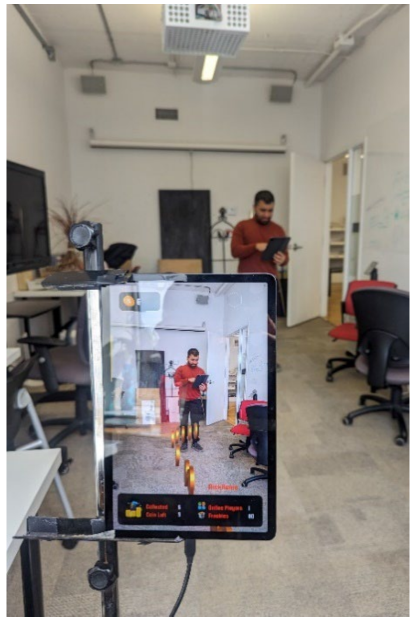
Concerning UI, most players were able to understand and participate in the game, but some individuals asked for the instruction on how to collect the coins. To address this issue, I have added a disappearing graphic in the start of the game that provide instructions on how to collect coins.

Conclusion

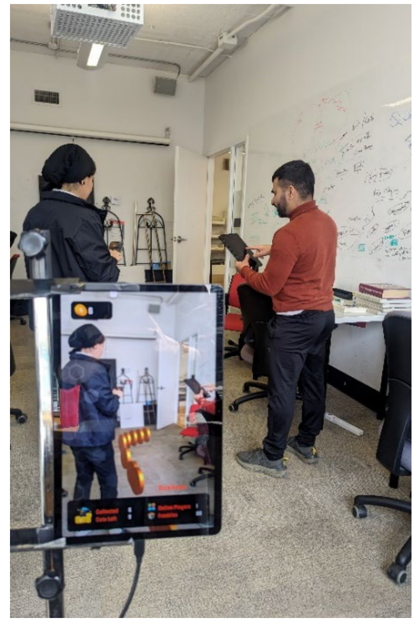
The creation process offered me a chance to evaluate AR frameworks and if these solutions are accessible enough to develop an AR game for small businesses. While initial prototypes were challenging because of my limited understanding of C# language and logic to create the game mechanics. The process started to progress after the basic logic was developed. One of the most important code logics that slowed the progress relates to the disappearance of coin in the multiuser environment. In the multiuser gameplay the game must account for changes made by other user and synchronize these changes across all users. Compared to conventional non-immersive games, AR game development require a challenging and time-consuming testing and debugging. The conventional games testing and debugging can be done in the game development engines (Unity3D) itself. However, the current state of AR development softwares are not sophisticated enough to provide this flexibility. To test each small change the AR application must be deployed to the target device and tested in the targeted environment. WebAR libraries do provide an alternative, but these libraries are not sophisticated enough to provide features like AreaTarget and multiuser gameplay.



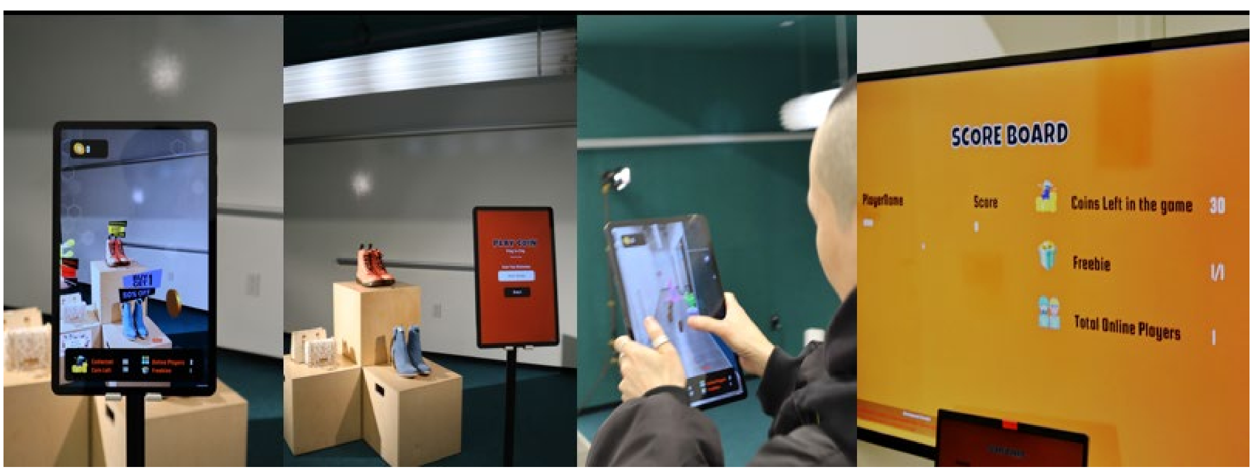
Testing the app in a large area, showing displacement of coins from floor level



Testing the game in the cluttered room including how the app will respond to the moving objects that were not included in the initial area scan for example human figures.



Testing to observe how players reacted to shared gameplay and to assess the app's capability to recognize the area with the addition of more than one moving figure. The results showed no impact on area recognition.



Picture taken at the exhibition showing multiple views and state of the game.

5.4 Game Development

The following section highlights some key development milestones and future game development strategies that I have taken to create a final version of the game.

5.4.1 Area Target

The conventional location-based AR experience uses GPS locations as a location variable to implement spatial positioning, along with plane detection techniques to enhance accuracy and context within the physical environment. This technique is suitable for outdoor games where precise accuracy is not required for example in Pokémon GO where typical positioning accuracy is within 3 to 5 meters. With regards to indoor AR experiences the GPS is not a reliable technology to implement. To overcome this issue this project utilizes the Vuforia AreaTarget techniques that are based on Simultaneous Localization and Mapping (SLAM). SLAM allows a device to map its environment while simultaneously keeping track of its own location within that space. Based on SLAM Vuforia Area Target utilizes LiDAR technology to create a 3D scan of the area that can later be used as a tracking method to track and augment spaces for AR experiences. Vuforia Area Target allows developers to easily scan the environment via LiDAR enabled devices such as iPhone or iPad pro. The scanned file can be exported to Unity3D to create AR.

5.4.2 Multiplayer Networking

The multiplayer capabilities are embedded using Photon Networking Engine for Unity 3D called Photon PUN2. Photon PUN provides an extensive set of tools and features that make it easier to develop networked multiplayer interaction. Photon PUN provides several ways to synchronize data between players. However, I am using Remote Procedure Calls (RPCs). This feature is pivotal for executing game logic on all clients simultaneously. For example, the SceneManager class from my game script uses RPCs to deactivate a collected coin across all clients, ensuring it disappears from every player's view once collected.

5.4.3 Scanning

To initiate the game development process, I began by scanning the area designated for prototype testing. Vuforia offers a developer tool named "Creator" designed to work seamlessly with the Vuforia Engine, streamlining the scanning procedure. This tool is exclusive to devices equipped with LiDAR technology; in my situation, I utilized an iPad Pro. The scanning operation is straightforward, merely necessitating that developers aim the device's camera at the area intended for scanning. Upon completion of the scan, the app can export a Unity package file which we need to develop the AR experience.

5.4.4 Collectable Instantiation

I am using the Spline component to generate Coins on a vector path. In my previous approach I placed the Coin game object manually on in the game environment, but that approach requires tedious amount of manual work. Instead, Unity Spline let you draw a vector path in the space and then using code we can populate coins along the vector path. This approach is selected to provide a guided track to the player. By utilizing Spline path, the game developer can curate players movements towards the targeted location.

The appendix section provides a step-by-step guide to develop the final version of the prototype.

Chapter 6

6.1 Conclusion

Beyond technical challenges, the range of applications for AR is still largely untapped. A survey (Chylinski et al., 2020) done in Germany among managers related to the adoption of AR marketing tools indicate the main reason of not using AR marketing is the lack of established AR marketing tools within their specific industry. In the retail sector, the use of AR has been mostly confined to 3D product visualizations and virtual try-on features, creating opportunities for designers and artists to speculate future of AR applications.

The prototype developed in this research speculate a retail scenario where users are encouraged to enter the store and engage in an AR game. While prototyping went according to speculated design, it provided some insights that shed some light on why AR technology has not kicked off yet. One the most prominent insights relates to the positioning ability of AR systems. The most famous AR game Pokémon Go uses GPS system to position virtual objects which has its limitation regarding it precision in positioning. This approach is useful for outdoor environments, but indoor AR experiences require a sophisticate approach. For indoor environments AR systems use area tracking, surface detection and image anchors to position virtual elements. In the current prototype I have experimented with area tracking approach. while this approach is sophisticated enough to create a seamless AR experience it has its limitation. During prototype development, I came to realize that AR applications are resource-intensive, causing rapid battery drainage and device overheating. This occurs because AR applications continually process the camera feed, demanding high processing power, which accelerates processor and memory functions. While newer phone devices have decent processing and memory capabilities, they often interrupt the AR game because of device over heating and battery drainage. In addition to device capabilities intensive development and debugging methods of AR application development are the key factors in the slow adoption of AR technology on a wide scale.

The current landscape of AR devices, mobile phones serve as the primary platform for delivering AR experiences. However, these devices typically only feature RGB cameras and for a more accurate spatial understanding, AR technology often requires depth sensors. While the latest Apple devices include LiDAR scanners to address this need, most current Android phones lack built-in LiDAR technology. Furthermore, AR technology demands continuous camera access to make sense of the surrounding, resulting in substantial consumption of battery power and processing resources. WebAR provide an alternative solution, but WebAR still lack the basic area and object tracking capabilities which are crucial for AR experiences to work. Including the steep learning curve associated with programing languages of WebAR. The advancement in Artificial Intelligence with its object recognition abilities may significantly improve the AR systems but it will take some time before AR application become ubiquitous. Currently there is no mainstream AR development framework that utilizes artificial intelligence as their primary approach for area and object recognition. On the other hand, a variety of consumer-grade devices specifically designed to recognize objects using AI are gradually being released including Meta smart glasses, INMO Air 2, and Envision Smart Glasses but these smart glasses do not offer Augmented Reality experience. The consumer grade glasses that offer Augmented and Mixed Reality experiences are still in its infancy and concerns related to cost and ergonomics remain significant barriers.

Responding to the second question of flow mediated by augmented reality and its influence on customer purchasing behaviour, I took the deeper dive into the literature review rather than taking a conventional approach of user testing. The second question gave me an opportunity to dig deeper into research that explore the phenomena of mental engagement, its relationship with technology and how technological tools with their emerging characteristics can persuade human behaviours. With regards to augmented reality, its ability to merge the sensory perception of intangible virtual object with surroundings tangible object, including AR ability to manipulate virtual object are the primary feature that induce flow. In addition, the novelty of AR technology was another factor that play a crucial role in user engagement of AR experiences. Although the second question gave me an opportunity to dive into literature it also provided an opportunity to ponder some fundamental questions that relates to empirical investigation of measuring flow experience, including its subdimensions. Given that each subdimension represents either a type of feeling or a psychophysiological reaction raise questions whether these qualities can be measured through surveys employing reductionist approach, including concerns related to sample size and demographic. The most intriguing question is related to the style of interrogation and the nature of questions. Can we ask direct questions to assess the psychophysiological reactions for example asking question like “do you think game was playful or enjoyable” or asking indirect questions that require a comprehensive study of human psychological functions and behaviour economics.

In thinking about flow and consumer behaviour, it is crucial to define the customer purchase journey (CPJ) and identify key touchpoints within it, determining how the game targets specific touchpoints. The literature suggests that these touchpoints often correspond to conative states, prompting user actions. The hypothesis is that by engaging users in a state of flow—generally associated with increased happiness and receptiveness—there's potential to encourage them to make additional purchases, thus potentially increasing retailer revenue.

6.2 Future Work

This research is the starting point to investigate commercial potential and persuasive nature of Augmented Reality games. The future work will continue to explore the large body of literature related to underlying psychological characteristics of consumer behaviour and Augmented Reality. Future prototype will utilize WebAR technology for app development and delivery. The web-based AR platforms represents a promising direction for making AR more accessible to small businesses. This shift could democratize the use of AR technologies, allowing for broader implementation without the barriers associated with app-based experiences. Looking ahead, the research work will investigate the how sociability of AR games can influence customer behaviour, including the adoptability of the AR games in retail sector.

References

Ahn, S. J., Bailenson, J. N., & Park, D. (2014). Short- and long-term effects of embodied experiences in immersive virtual environments on environmental locus of control and behavior. Computers in Human Behavior, 39, 235–245. https://doi.org/10.1016/j.chb.2014.07.025

Beatriz Costa-Lima and Mary Hudetz, The 'Pokemon Go' Files: 10 Tales of Trespass, Robbery, Murder, and More, INS. J. (July 15, 2016), http://www.insurancejournal.com/news/national/2016/07/15/420198.htm

Bengler, B., & Bryan-Kinns, N. (2013). Designing collaborative musical experiences for broad audiences. *Proceedings of the 9th ACM Conference on Creativity & Cognition*, 234–242. https://doi.org/10.1145/2466627.2466633

Bishop, L. (2018). Collaborative Musical Creativity: How Ensembles Coordinate Spontaneity. *Frontiers in Psychology*, *9*, 1285. https://doi.org/10.3389/fpsyg.2018.01285

Blaine, T., & Fels, S. (2017). 2003: Contexts of Collaborative Musical Experiences. In A. R. Jensenius & M. J. Lyons (Eds.), *A NIME Reader* (Vol. 3, pp. 71–87). Springer International Publishing. https://doi.org/10.1007/978-3-319-47214-0_6

Barhorst, J., McLean, G., Shah, E., & Mack, R. (2021). Blending the real world and the virtual world: Exploring the role of flow in augmented reality experiences. *Journal of Business Research*, *122*, 423–436. https://doi.org/10.1016/j.jbusres.2020.08.041

Briggs, F. (2023, June 20). Interactive retail stores create stand-out customer experiences. *Samsung Business Insights*. https://insights.samsung.com/2023/06/20/interactive-retail-stores-create-stand-out-customer-experiences-2/

Cachero-Martínez, S., & Vázquez-Casielles, R. (2018). Developing the Marketing Experience to Increase Shopping Time: The Moderating Effect of Visit Frequency. Administrative Sciences, 8(4), Article 4. https://doi.org/10.3390/admsci8040077

Chen, H., Wigand, R., & Nilan, M. (n.d.). *Exploring Web users ' optimal flow experiences 263*. Retrieved November 21, 2023, from https://www.semanticscholar.org/paper/Exploring-Web-users-%27-optimal-flow-experiences-263-Chen-Wigand/2b5e6cf9b5f670417e0d239d1101930dd9c25d3a

Chen, L., Gillenson, M.L., & Sherrell, D. (2002). Enticing online consumers: an extended technology acceptance perspective. Information & Management, 39(8), 705–719.

Chen, W. (2016, July 11). How Pokemon Go Is Driving Insane Amounts of Sales at Small, Local Businesses. Inc.Com. https://www.inc.com/walter-chen/pok-mon-go-is-driving-insane-amounts-of-sales-at-small-local-businesses-here-s-h.html

Cheng, Y., Yan, Y., Yi, X., Shi, Y., & Lindlbauer, D. (2021). SemanticAdapt: Optimization-based Adaptation of Mixed Reality Layouts Leveraging Virtual-Physical Semantic Connections. *The 34th Annual ACM Symposium on User Interface Software and Technology*, 282–297. https://doi.org/10.1145/3472749.3474750

Choi, W. J., Jerath, K., & Sarvary, M. (n.d.). Consumer Purchase Journey, Targeted Advertising, and Privacy Choices.

Chung, J., & Tang, F. B. (2004). Antecedents of perceived playfulness: An exploratory study on user acceptance of general information-searching websites. Information and Management, 41(7), 869–881.

Chylinski, M., Heller, J., Hilken, T., Keeling, D. I., Mahr, D., & de Ruyter, K. (2020). Augmented reality marketing: A technology-enabled approach to situated customer experience. *Australasian Marketing Journal (AMJ)*, *28*(4), 374–384. https://doi.org/10.1016/j.ausmj.2020.04.004

Cocchiara, D., & Turchet, L. (2022). Democratizing access to collaborative music making over the network using air instruments. *AudioMostly 2022*, 211–218. https://doi.org/10.1145/3561212.3561227

Creating brand engagement through in-store gamified customer experiences. (2019). *Journal of Retailing and Consumer Services*, *50*, 122–130. https://doi.org/10.1016/j.jretconser.2019.05.006

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. MIS Quarterly, 13(3), 319–339

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008

De Canio, F., Fuentes-Blasco, M., & Martinelli, E. (2021). Engaging shoppers through mobile apps: The role of gamification. *International Journal of Retail & Distribution Management*, *49*(7), 919–940. https://doi.org/10.1108/IJRDM-09-2020-0360

Deloitte. (2022). The Future of Exploration: How Augmented Reality is Reshaping Our World. https://www2.deloitte.com/content/dam/Deloitte/dk/Documents/Grabngo/Digital%20Reality%20GrabNGo_2019_030419.pdf:

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). *From Game Design Elements to Gamefulness: Defining Gamification*. *11*, 9–15. https://doi.org/10.1145/2181037.2181040

Du, Z., Liu, J., & Wang, T. (2022). Augmented Reality Marketing: A Systematic Literature Review and an Agenda for Future Inquiry. *Frontiers in Psychology*, *13*, 925963. https://doi.org/10.3389/fpsyg.2022.925963

Dunham, J., Xu, J., Papangelis, K., & Schwartz, D. I. (2022). Advertising in Location-Based Games: An Exploration in Pokémon GO. *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems*, 1–6. https://doi.org/10.1145/3491101.3519663

Ellenberg, M. O., Satkowski, M., Luo, W., & Dachselt, R. (2023). Spatiality and Semantics—Towards Understanding Content Placement in Mixed Reality. *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–8. https://doi.org/10.1145/3544549.3585853

Emrich, T. & Niantic. (2022). *How Augmented Reality Will Save the Holidays for Brick-and-Mortar Retail*. Retrieved February 5, 2024, from https://www.adweek.com/sponsored/how-augmented-reality-will-save-the-holidays-for-brick-and-mortar-retail/

Esteban-Millat, I., Martínez-López, F. J., Luna, D., & Rodríguez-Ardura, I. (2014). The Concept of Flow in Online Consumer Behavior. In F. J. Martínez-López (Ed.), *Handbook of Strategic e-Business Management* (pp. 371–402). Springer. https://doi.org/10.1007/978-3-642-39747-9_17

Exploring Web users' optimal flow experiences. (n.d.). Retrieved November 21, 2023, from https://www.researchgate.net/publication/220437131_Exploring_Web_users%27_optimal_flow_experiences

Finneran, C. M., & Zhang, P. (2005). Flow in Computer-Mediated Environments: Promises and Challenges. *Communications of the Association for Information Systems*, *15*. https://doi.org/10.17705/1CAIS.01504

Frith, J. (2017). The digital "lure": Small businesses and Pokémon Go. Mobile Media & Communication, 5(1), 51–54. https://doi.org/10.1177/2050157916677861

Gameful Experience in Gamification: Construction and Validation of a Gameful Experience Scale [GAMEX]—ScienceDirect. (n.d.). Retrieved November 21, 2023, from https://www.sciencedirect.com/science/article/pii/S1094996818300124

Gao, L., & Bai, X. (2014). Online consumer behaviour and its relationship to website atmospheric induced flow: Insights into online travel agencies in China. *Journal of Retailing and Consumer Services*, *21*(4), 653–665.

Ghani, J. A., & Deshpande, S. P. (1994). Task Characteristics and the Experience of Optimal Flow in Human—Computer Interaction. *The Journal of Psychology*, *128*(4), 381–391. https://doi.org/10.1080/00223980.1994.9712742

Godøy, R. I., Haga, E., & Jensenius, A. R. (2006). Playing "Air Instruments": Mimicry of Sound-Producing Gestures by Novices and Experts. In S. Gibet, N. Courty, & J.-F. Kamp (Eds.), *Gesture in Human-Computer Interaction and Simulation* (Vol. 3881, pp. 256–267). Springer Berlin Heidelberg. https://doi.org/10.1007/11678816_29

Halan, S., Rossen, B., Cendan, J., & Lok, B. (2010). High Score! - Motivation Strategies for User Participation in Virtual Human Development (Vol. 6356, p. 488). https://doi.org/10.1007/978-3-642-15892-6_52

Hamari, J., & Koivisto, J. (2014). Measuring flow in gamification: Dispositional Flow Scale-2. *Computers in Human Behavior*, *40*, 133–143. https://doi.org/10.1016/j.chb.2014.07.048

Hamari, J., & Koivisto, J. (2015). Why do people use gamification services? *International Journal of Information Management*, *35*(4), 419–431. https://doi.org/10.1016/j.ijinfomgt.2015.04.006

Hamari, J., Malik, A., Koski, J., & Johri, A. (2019). Uses and Gratifications of Pokémon Go: Why do People Play Mobile Location-Based Augmented Reality Games? International Journal of Human–Computer Interaction, 35(9), 804–819. https://doi.org/10.1080/10447318.2018.1497115

Hedonic Consumption: Emerging Concepts, Methods and Propositions. (2023).

Heller, J., Chylinski, M., De Ruyter, K., Mahr, D., & Keeling, D. I. (2019). Let Me Imagine That for You: Transforming the Retail Frontline Through Augmenting Customer Mental Imagery Ability. *Journal of Retailing*, *95*(2), 94–114. https://doi.org/10.1016/j.jretai.2019.03.005

Henderson, T., & Bhatti, S. (2001). Modelling user behaviour in networked games. *Proceedings of the Ninth ACM International Conference on Multimedia*, 212–220. https://doi.org/10.1145/500141.500175

Hilken, T., Keeling, D. I., de Ruyter, K., Mahr, D., & Chylinski, M. (2020). Seeing eye to eye: Social augmented reality and shared decision making in the marketplace. *Journal of the Academy of Marketing Science*, *48*(2), 143–164. https://doi.org/10.1007/s11747-019-00688-0

Hirschman, E. C., & Holbrook, M. B. (1982). Hedonic Consumption: Emerging Concepts, Methods and Propositions. *Journal of Marketing*, *46*(3), 92–101. https://doi.org/10.1177/002224298204600314

Hoch, S. J., Kim, B.-D., Montgomery, A. L., & Rossi, P. E. (1995). Determinants of Store-Level Price Elasticity. *Journal of Marketing Research*, *32*(1), 17–29. https://doi.org/10.2307/3152107

Hoffman, D. L., & Novak, T. P. (1996). Marketing in Hypermedia Computer-Mediated Environments: Conceptual Foundations. *Journal of Marketing*, *60*(3), 50–68. https://doi.org/10.2307/1251841

Hoffman, D. L., & Novak, T. P. (2009). Flow Online: Lessons Learned and Future Prospects. *Journal of Interactive Marketing*, *23*(1), 23–34. https://doi.org/10.1016/j.intmar.2008.10.003

Hoffmann, S., & Mai, R. (2022). Consumer behavior in augmented shopping reality. A review, synthesis, and research agenda. *Frontiers in Virtual Reality*, *3*. https://www.frontiersin.org/articles/10.3389/frvir.2022.961236

Hoffmann, S., Joerß, T., Mai, R., & Akbar, P. (2022). Augmented reality-delivered product information at the point of sale: When information controllability backfires. *Journal of the Academy of Marketing Science*, *50*(4), 743–776. https://doi.org/10.1007/s11747-022-00855-w

Hogberg, Johan & Ramberg, Marcus Olsson & Gustafsson, Anders & WÃ¤stlund, Erik, 2019. "Creating brand engagement through in-store gamified customer experiences," Journal of Retailing and Consumer Services, Elsevier, vol. 50(C), pages 122-130.

Huotari, K., & Hamari, J. (2017). A definition for gamification: Anchoring gamification in the service marketing literature. *Electronic Markets*, *27*(1), 21–31. https://doi.org/10.1007/s12525-015-0212-z

Huotari, K., Hamari, J. A definition for gamification: anchoring gamification in the service marketing literature. *Electron Markets* **27**, 21–31 (2017). https://doi.org/10.1007/s12525-015-0212-z

Ip, B. (2009). Product placement in interactive games. *Proceedings of the International Conference on Advances in Computer Entertainment Technology*, 89–97. https://doi.org/10.1145/1690388.1690404

Ipeirotis, P.G. and Gabrilovich, E. (2015), "Quizz:targeted crowdsourcing with a billion (potential) users",inInternational Conference on World Wide Web, pp. 143-154.

Jack, R. H., Harrison, J., Morreale, F., & McPherson, A. (n.d.). Democratising DMIs: The relationship of expertise and control intimacy.

Jang, S., Kitchen, P. J., & Kim, J. (2018). The effects of gamified customer benefits and characteristics on behavioral engagement and purchase: Evidence from mobile exercise application uses. *Journal of Business Research*, *92*, 250–259. https://doi.org/10.1016/j.jbusres.2018.07.056

Javornik, A. (2016a). Augmented reality: Research agenda for studying the impact of its media characteristics on consumer behaviour. *Journal of Retailing and Consumer Services*, *30*, 252–261. https://doi.org/10.1016/j.jretconser.2016.02.004

Javornik, A. (2016b). Augmented reality: Research agenda for studying the impact of its media characteristics on consumer behaviour. *Journal of Retailing and Consumer Services*, *30*, 252–261. https://doi.org/10.1016/j.jretconser.2016.02.004

Keogh, B. (2017). Pokémon Go, the novelty of nostalgia, and the ubiquity of the smartphone. Mobile Media & Communication, 5(1), 38–41. https://doi.org/10.1177/2050157916678025

Koetsier, J. (n.d.). *91% Of Us Hate Being Forced To Install Apps To Do Business, Costing Brands Billions*. Forbes. Retrieved November 30, 2023, from https://www.forbes.com/sites/johnkoetsier/2021/02/15/91-of-us-hate-being-forced-to-install-apps-to-do-business-costing-brands-billions/

Koufaris, M. (2002). Applying the Technology Acceptance Model and Flow Theory to Online Consumer Behavior. *Information Systems Research*, *13*(2), 205–223.

Kumar, H. (2021). Augmented reality in online retailing: A systematic review and research agenda. International Journal of Retail & Distribution Management.

Kusumawardani, K. A., Widyanto, H. A., & Tambunan, J. E. G. (2023). The role of gamification, social, hedonic and utilitarian values on e-commerce adoption. *Spanish Journal of Marketing - ESIC*, *27*(2), 158–177. https://doi.org/10.1108/SJME-09-2022-0188

Laato, S., Islam, A. K. M. N., & Laine, T. H. (2022). Playing location-based games is associated with psychological well-being: An empirical study of Pokémon GO players. Behaviour & Information Technology, 41(9), 1888–1904. https://doi.org/10.1080/0144929X.2021.1905878

Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented Reality and Gamification in Education: A Systematic Literature Review of Research, Applications, and Empirical Studies. *Applied Sciences*, *12*(13), Article 13. https://doi.org/10.3390/app12136809

Lavidge, R. J., & Steiner, G. A. (2023). A Model for Predictive Measurements of Advertising Effectiveness. *JOURNAL OF MARKETING*.

Lavoye, V., Mero, J., & Tarkiainen, A. (2021). Consumer behavior with augmented reality in retail: A review and research agenda. *The International Review of Retail, Distribution and Consumer Research*, *31*(3), 299–329. https://doi.org/10.1080/09593969.2021.1901765

Lee, B., Hu, X., Cordeil, M., Prouzeau, A., Jenny, B., & Dwyer, T. (2021). Shared Surfaces and Spaces: Collaborative Data Visualisation in a Co-located Immersive Environment. *IEEE Transactions on Visualization and Computer Graphics*, *27*(2), 1171–1181. https://doi.org/10.1109/TVCG.2020.3030450

Leigh, S., & Maes, P. (2015). AfterMath: Visualizing Consequences of Actions through Augmented Reality. *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, 941–946. https://doi.org/10.1145/2702613.2732695

Lin, W., Lo, W. T., & Yueh, H. P. (2022). Effects of learner control design in an AR-based exhibit on visitors' museum learning. *PloS one*, *17*(10), e0274826. https://doi.org/10.1371/journal.pone.0274826

Mallick, S. (2017). Augmenting Property Law: Applying the Right to Exclude in the Augmented Reality Universe.

Mathwick, C., & Rigdon, E. (2004). Play, Flow, and the Online Search Experience. *Journal of Consumer Research*, *31*(2), 324–332. https://doi.org/10.1086/422111

Matin, A., Maduro, M., De Leon Pereira, R., & Tremblay-Savard, O. (2020). Effect of Timer, Top Score and Leaderboard on Performance and Motivation in a Human Computing Game. International Conference on the Foundations of Digital Games, 1–10. https://doi.org/10.1145/3402942.3403000

McLean, G., & Wilson, A. (2019). Shopping in the digital world: Examining customer engagement through augmented reality mobile applications. *Computers in Human Behavior*, *101*, 210–224. https://doi.org/10.1016/j.chb.2019.07.002

Michie, S., Van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, *6*(1), 42. https://doi.org/10.1186/1748-5908-6-42

Michon, R., Smith, J., Wright, M., Chafe, C., Granzow, J., & Wang, G. (2017). Mobile Music, Sensors, Physical Modeling, and Digital Fabrication: Articulating the Augmented Mobile Instrument. *Applied Sciences*, *7*(12), 1311. https://doi.org/10.3390/app7121311

Mihić, M., Anić, I.-D., & Kursan Milaković, I. (2018). TIME SPENT SHOPPING AND CONSUMER CLOTHING PURCHASING BEHAVIOUR. Ekonomski Pregled, 69(2), 89–105.

nime01Proceedings. (n.d.).

Novak, T. P., Hoffman, D. L., & Yung, Y. F. (2000). Measuring the customer experience in online environments: A structural modeling approach. Marketing Science, 19(1), 22–42.

Oliveira, W., Pastushenko, O., Rodrigues, L., Toda, A. M., Palomino, P. T., Hamari, J., & Isotani, S. (2021). *Does gamification affect flow experience? A systematic literature review* (arXiv:2106.09942). arXiv. http://arxiv.org/abs/2106.09942

Ozkara, B. Y., Ozmen, M., & Kim, J. W. (2017). Examining the effect of flow experience on online purchase: A novel approach to the flow theory based on hedonic and utilitarian value. *Journal of Retailing and Consumer Services*, *37*, 119–131. https://doi.org/10.1016/j.jretconser.2017.04.001

Paasovaara, S., Jarusriboonchai, P., & Olsson, T. (2017). Understanding collocated social interaction between Pokémon GO players. Proceedings of the 16th International Conference on Mobile and Ubiquitous Multimedia, 151–163. https://doi.org/10.1145/3152832.3152854

Park, S., & Kim, S. (2021). Leaderboard Design Principles to Enhance Learning and Motivation in a Gamified Educational Environment: Development Study. JMIR Serious Games, 9(2), e14746. https://doi.org/10.2196/14746

Peter Vorderer, Tilo Hartmann, and Christoph Klimmt. (2003). Explaining the enjoyment of playing video games: the role of competition. In Proceedings of the second international conference on Entertainment computing (ICEC '03). Carnegie Mellon University, USA, 1–9.

Pierce, A. (1972). John Cage: Edited by Richard Kostelanetz. New York: Frederick A. Praeger, Publishers, 1970.237 pp. Illustrations, chronology, catalog of Cage's compositions, discography, bibliographies, index. Hard cover, $12.50, soft cover, $4.95. *Music Educators Journal*, *58*(5), 79–83. https://doi.org/10.2307/3393975

Ponis, S. T., Plakas, G., Agalianos, K., Aretoulaki, E., Gayialis, S. P., & Andrianopoulos, A. (2020). Augmented Reality and Gamification to Increase Productivity and Job Satisfaction in the Warehouse of the Future. *Procedia Manufacturing*, *51*, 1621–1628. https://doi.org/10.1016/j.promfg.2020.10.226

Qin, Y. (2021). Attractiveness of game elements, presence, and enjoyment of mobile augmented reality games: The case of Pokémon Go. Telematics and Informatics, 62, 101620. https://doi.org/10.1016/j.tele.2021.101620

Quinn, J. (2016). Identity of Pokemon Go Players: How Social Gaming Affects Behavior. Pop Culture Intersections. https://scholarcommons.scu.edu/engl_176/19

Ramadhan, A. D., Permanasari, A. E., & Wibirama, S. (2022). Gamification Opportunity in Augmented Reality-Based Learning Media: A Review. *2022 2nd International Conference on Intelligent Cybernetics Technology & Applications (ICICyTA)*, 117–122. https://doi.org/10.1109/ICICyTA57421.2022.10037922

Rauschnabel, P. A., Babin, B. J., Tom Dieck, M. C., Krey, N., & Jung, T. (2022). What is augmented reality marketing? Its definition, complexity, and future. *Journal of Business Research*, *142*, 1140–1150. https://doi.org/10.1016/j.jbusres.2021.12.084

Rauschnabel, P. A., Felix, R., & Hinsch, C. (2019). Augmented reality marketing: How mobile AR-apps can improve brands through inspiration. *Journal of Retailing and Consumer Services*, *49*, 43–53. https://doi.org/10.1016/j.jretconser.2019.03.004

Rettie, R. (2001). An exploration of flow during Internet use. *Internet Research*, *11*(2), 103–113. https://doi.org/10.1108/10662240110695070

Riar, M., Xi, N., Korbel, J. J., Zarnekow, R., & Hamari, J. (2023). Using augmented reality for shopping: A framework for AR induced consumer behavior, literature review and future agenda. *Internet Research*, *33*(1), 242–279. https://doi.org/10.1108/INTR-08-2021-0611

Romano, B., Sands, S., & Pallant, J. I. (2021). Augmented reality and the customer journey: An exploratory study. *Australasian Marketing Journal*, *29*(4), 354–363. https://doi.org/10.1016/j.ausmj.2020.06.010

Senecal, S., Gharbi, J.-E., & Nantel, J. (2002). The Influence of Flow on Hedonic and Utilitarian Shopping Values. *ACR North American Advances*, *NA-29*. https://www.acrwebsite.org/volumes/8609/volumes/v29/NA-29/full

Shah Alam, S., Masukujjaman, M., Sayeed, M. S., Omar, N. A., Ayob, A. H., & Wan Hussain, W. M. H. (2023). Modeling Consumers' Usage Intention of Augmented Reality in Online Buying Context: Empirical Setting with Measurement Development. *Journal of Global Marketing*, *36*(1), 1–24. https://doi.org/10.1080/08911762.2022.2087580

Sharafi, P., Hedman, L., & Montgomery, H. (2006). Using information technology: Engagement modes, flow experience, and personality orientations. Computers in Human Behavior, 22(5), 899–916.

Słowiński, P., Grindley, B., Muncie, H., Harris, D., Vine, S., & Wilson, M. (2022). Assessment of cognitive biases in augmented reality: Beyond eye tracking. *Journal of Eye Movement Research*, *15*(3). https://doi.org/10.16910/jemr.15.3.4

Sun, B., Zhang, Y., & Zheng, L. (2023). Relationship between time pressure and consumers' impulsive buying—Role of perceived value and emotions. Heliyon, 9(12), e23185. https://doi.org/10.1016/j.heliyon.2023.e23185

Tang, J., & Zhang, P. (2018). Exploring the relationships between gamification and motivational needs in technology design. International Journal of Crowd Science, 3(1), 87–103. https://doi.org/10.1108/IJCS-09-2018-0025

Tarka, P., Harnish, R. J., & Babaev, J. (2023). Hedonism, hedonistic shopping experiences and compulsive buying tendency: A demographics-based model approach. *Journal of Marketing Theory and Practice*, *31*(2), 197–222. https://doi.org/10.1080/10696679.2022.2026791

The Impact of an Augmented-Reality Game on Local Businesses: A Study of Pokémon Go on Restaurants | Information Systems Research. (n.d.). Retrieved February 8, 2024, from https://pubsonline.informs.org/doi/10.1287/isre.2021.1004

To, P.-L., & Sung, E.-P. (2015). Internet Shopping: A Study Based On Hedonic Value and Flow Theory. *International Journal of Economics and Management Engineering*, *9*(7).

Toups Dugas, P. O., Crenshaw, N. K., Wehbe, R. R., Tondello, G. F., & Nacke, L. E. (2016). "The Collecting Itself Feels Good": Towards Collection Interfaces for Digital Game Objects. *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play*, 276–290. https://doi.org/10.1145/2967934.2968088

Tseng, T. H., Hsieh, S. H., & Lee, C. T. (2021). How gamified branded applications drive marketing effectiveness? *Marketing Intelligence & Planning*, *39*(5), Article 5. https://doi.org/10.1108/MIP-09-2020-0407

Turchet, L., Fischione, C., Essl, G., Keller, D., & Barthet, M. (2018). Internet of Musical Things: Vision and Challenges. *IEEE Access*, *6*, 61994–62017. https://doi.org/10.1109/ACCESS.2018.2872625

Vella, K., Johnson, D., Cheng, V. W. S., Davenport, T., Mitchell, J., Klarkowski, M., & Phillips, C. (2019). A Sense of Belonging: Pokémon GO and Social Connectedness. Games and Culture, 14(6), 583–603. https://doi.org/10.1177/1555412017719973

Vieira, V. A., Rafael, D. N., & Agnihotri, R. (2022). Augmented reality generalizations: A meta-analytical review on consumer-related outcomes and the mediating role of hedonic and utilitarian values. *Journal of Business Research*, *151*, 170–184. https://doi.org/10.1016/j.jbusres.2022.06.030

Violent Video Games and Young People—Harvard Health Publishing. (2010, October 1). Harvard Health. https://www.health.harvard.edu/newsletter_article/violent-video-games-and-young-people.

Wang, M., Marsden, J., Oguz, E., & Thomas, B. (2023). The Role of Interactive Technology in Retail Design: A Case Study Within the Fashion Sector. *Journal of Marketing Development and Competitiveness*, *17*(4), Article 4. https://doi.org/10.33423/jmdc.v17i4.6645

Wang, Z., & Scheepers, H. (2012). Understanding the Intrinsic Motivations of User Acceptance of Hedonic Information Systems: Towards a Unified Research Model. *Communications of the Association for Information Systems*, *30*. https://doi.org/10.17705/1CAIS.03017

Weinberg, G., Aimi, R., & Jennings, K. (n.d.). The Beatbug Network – A Rhythmic System for Interdependent Group Collaboration.

Xambó, A., Laney, R., & Dobbyn, C. (2010). TOUCHtr4ck: Democratic collaborative music. *Proceedings of the Fifth International Conference on Tangible, Embedded, and Embodied Interaction*, 309–312. https://doi.org/10.1145/1935701.1935773

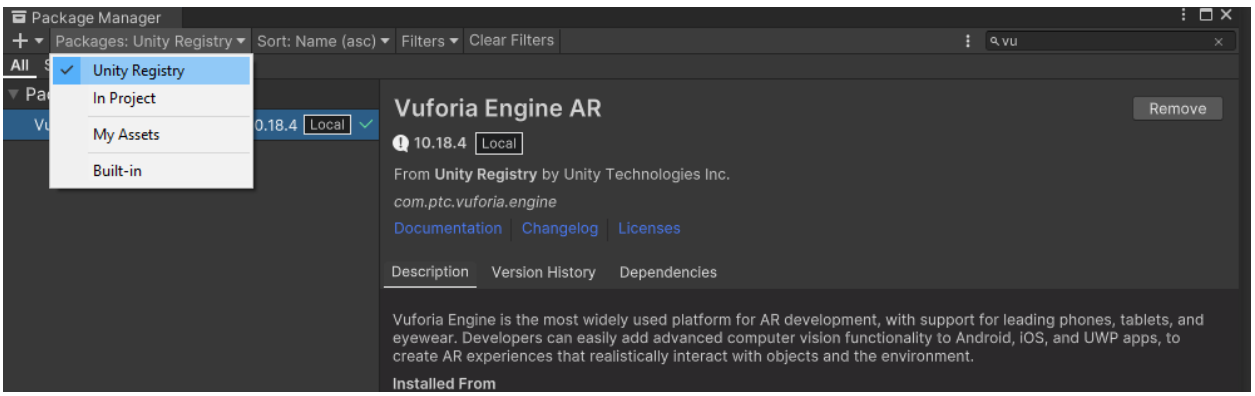
Appendix

Game Development

The following section highlights some key development milestones and future game development strategies that I have taken to create a final version of the game.

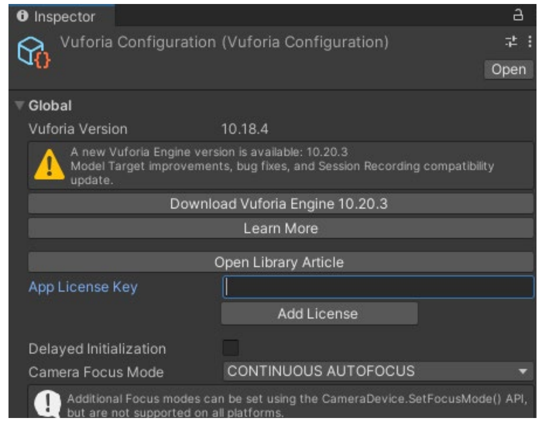
Initial Setup

Before importing the AreaTarget file, Vuforia Engine requires developers to create a developer account on their website to get a license key which is necessary to activate Voforia Unity Extension. The Vuforia Unity Extension can be installed from the Package Manager in the Unity Editor.

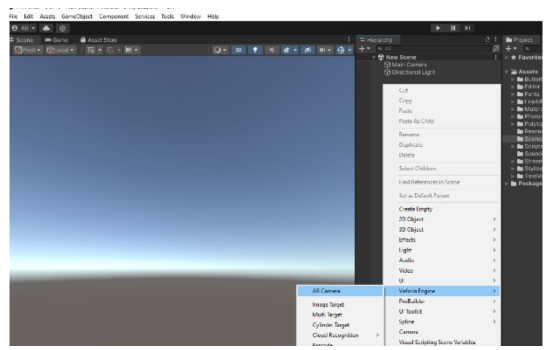


When installing any new extension to your unity project make sure to change package location to "Unity Registry" to find the extension from the unity Extension registry. By default, the package manager is set to show the extensions that are already installed in the current project.

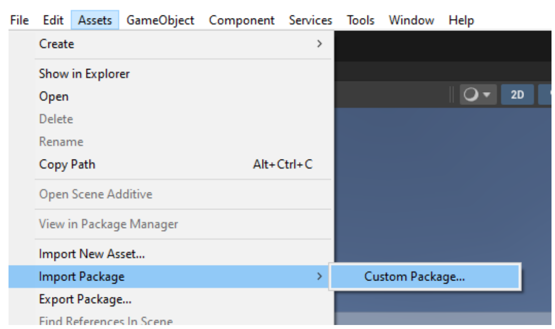
After successfully installing the Vuforia AR Engine click on Windows > Vuforia Configuration to open the Vuforia Engine inspector tab, copy the developer license key from the website and paste it here.



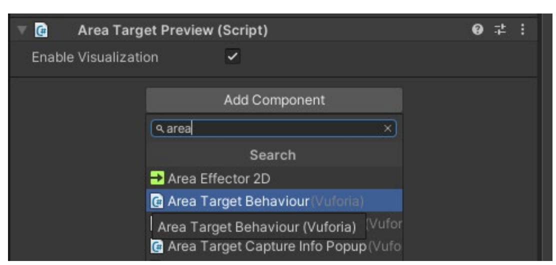
Create a new Scene and a new AR camera in the scene hierarchy by right clicking in the hierarchy and choosing Vuforia Engine > AR Camera



Now it's time to import the scanned file, to import the scanned file into Unity Editor click on Assets > import Packages > Custom Package



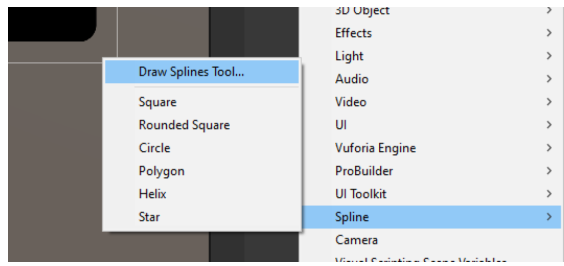
To add the imported scanned file into Scene, Create a empty Gameobject in the Scene Hierarchy and in the inspector window add a component called "Area Target Behaviour" this component will let you select the imported file of scanned area.



In order to add collectable items in the AR environment create an empty game object as a child to the previously created game object which has the “Area Target Behaviour” and name it “Collectables”. All collectable items will go under this game object.

Collectable Instantiation

I am using the Spline component to generate Coins on a vector path. In my previous approach I placed the Coin game object manually on in the game environment, but that approach requires tedious amount of manual work. Instead, Unity Spline let you draw a vector path in the space and then using code we can populate coins along the vector path. This approach is selected to provide a guided track to the player. By utilizing Spline path, the game developer can curate players movements towards the targeted location.



Spline is not a default component of Unity Editor, to add it first we need to install the Spline Extension from the Unity Package Manager. After installing the Spline Extension Right click in the scene hierarchy and select Spline, here we can use different ways to create spline, I am using Spline Draw Tool to draw the spline path in the scene. Draw the spine as a child of game object “Collectables” to keep the hierarchy organized.

Create a new script file GamePlay.cs in the “Scripts” folder and add it to “Collectables”. First Add Spline library in the header. Create a public variable called SpineContainer, this will create an input field in the inspector window of “Collectables”. Drag and drop the spline gameobject from scene hierarchy to this input filed. This is how the script will know which spine component we are referring to. The following code will instantiate 20 coins on the spline path.

```
1 reference
private void CreateSplineAndCoins()
{
    for (float t = 0; t <= 1; t += 0.05f)
    {
        Vector3 pointOnSpline = spline.EvaluatePosition(t);
        // Use standard Unity Instantiate method for local instantiation
        GameObject newCoin = Instantiate(Resources.Load("c3") as GameObject, pointOnSpline, Quaternion.identity);
        newCoin.name = "Spline_" + t;
        newCoin.transform.SetParent(parentObject, false);
        instantiatedCoin.Add(newCoin);
    }
}
```

In the Unity Environment, the total length of a spline is treated as "1". The code segments the spline into 20 equal parts by incrementally increasing the variable `t` by 0.05 in a for loop. This process uniformly spaces and instantiates copies of the GameObject named "C3" along the spline. "C3" denotes a Coin GameObject. The instantiated coine names are then added to an array named `instantiatedCoin`. This array will be used for the identification and deactivation of a specific coin that has been tapped by the player.

In next section we will use the “**`RaycastHit`**” method to detect the tapped coin to deactivate

```
if (Input.touchCount > 0 && Input.touches[0].phase == TouchPhase.Began)
{
    Ray ray = Camera.main.ScreenPointToRay(Input.GetTouch(0).position);
    RaycastHit Hit;
    if (Physics.Raycast(ray, out Hit))
    {
        PhotonView childPhotonView = Hit.transform.GetComponent<PhotonView>();
        collectabelName = Hit.transform.name;

        if (childPhotonView != null)
        {
            CollectCoin();

            networkUpdate2.text = "Locally detected: " + childPhotonView.ViewID;

            myphotonView.RPC("DeactivateCollectibleRPC", RpcTarget.All, childPhotonView.ViewID, collectabelName);
            networkUpdate3.text = "RPC sent out: " + childPhotonView.ViewID;


        }
    }
}
```

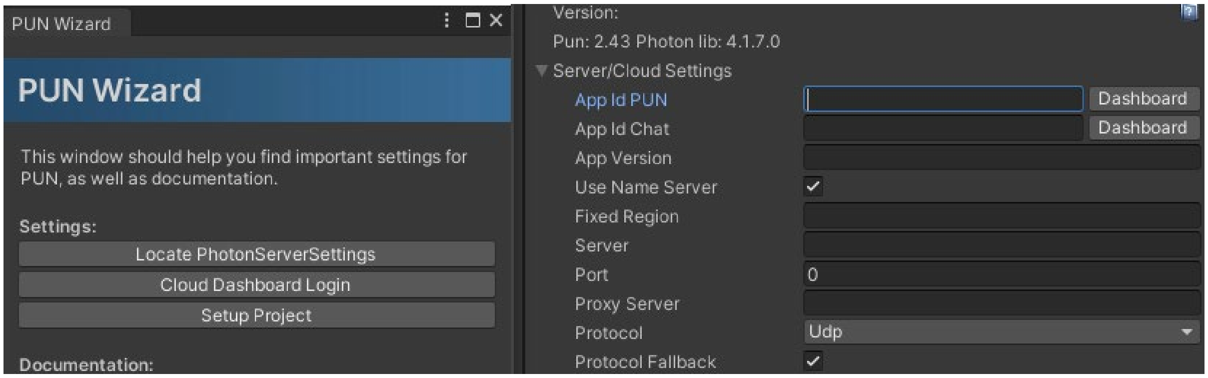
The above code used Unity RaycastHit method to detect which component is tapped. To learn more about check Unity RaycastHit Documentation. The above code will detect the name of the tapped item and send it to the RPC (Remote Procedural Call) method.

Remote Procedural Call

In the context of Photon PUN (Photon Unity Networking), RPC (Remote Procedure Call) refers to a method used to execute code across the network, allowing one client in a multiplayer game to run functions on other clients' machines. It is integral to synchronizing actions and game state across all players in a session, ensuring that multiplayer experiences are cohesive and interactive.

Photon Networking

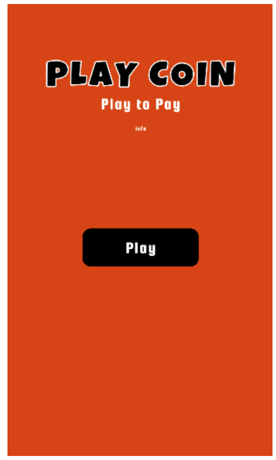
To add multiplayer features, this prototype utilizes the Photon Unity Networking (PUN) framework. This framework offers ready-made methods for creating multiplayer game sessions. The initial step in integrating PUN involves setting up a developer account, which enables you to produce the necessary license and App keys for integrating the Photon Engine into your Unity project. To install Photon PUN go to Unity Asset Store and search Photon PUN. From here you can add Photon PUN2 to your project. After installing PUN2 click on Window> Photon Unity Networking > PUN Wizard. Click on "Locate PhtonServerSettings" and past the App id.

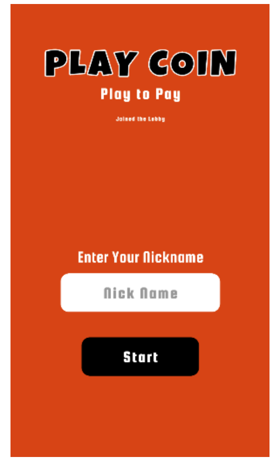


To learn more about this go to Photon Engine Documentation

This prototype uses a separate unity Scene to initiate networking protocol. In the App hierarchy it is the first scene. Start by creating a new scene in the "Scene" folder. Call it "Home". The home scene will take care of all initial networking setup. In the scene hierarchy create a empty gameobject and rename is "NetworkManager". Now create a new script file "NetworkManger.cs" in the script folder and drag and drop it on the "Network Manager" gameobject in the scene hierarchy. In the script header import the Photon.Pun and Photon.Realtime classes. Change the `MonoBehaviour` to `MonoBehaviourPunCallbacks.` `MonoBehaviour` is the base class of Unity Engine namespace and provides access to Unity's scripting API, including game object manipulation, event functions like `Start()`, `Update()`, `Awake()`, and many others. `MonoBehaviourPunCallbacks` is an extension of MonoBehaviour specific to the Photon Unity Networking (PUN) framework. It provides a set of callback functions related to Photon's networking events, such as connecting to the Photon server, joining rooms, and other multiplayer-related events.

Photon Engine makes it very simple to start a multiplayer game. The following function will be used to establish a connection with the Photon PUN server to start the networked environment for multiplayer game.





The `ConnectToServer()` function is triggered once the player clicks the "Play" button. First, this function disables the play button to prevent repeated clicks that could lead to the function being executed multiple times, potentially causing networking problems. Following this, it utilizes Photon Network's built-in method to establish a connection with the server, simultaneously updating the on-screen text to keep the user informed about the status of the connection process. This strategy enhances the user experience by ensuring that players are continuously aware of what is happening during the connection phase.

```
0 references
public void ConnectToServer()
{
    playbutton.SetActive(false);
    PhotonNetwork.ConnectUsingSettings();
    networkUpdate.text = "Trying To Connect to server...";
    Debug.Log("Trying To Connect to server...");
}
```

```
4 references
public override void OnJoinedLobby()
{
    base.OnJoinedLobby();
    Debug.Log("we Joined the Lobby");
    networkUpdate.text = "Joined the Lobby";
    roomUI.SetActive(true);
}
```

```
4 references
public override void OnConnectedToMaster()
{
    Debug.Log("Connected to Server.");
    networkUpdate.text = "Connected to Server.";
    base.OnConnectedToMaster();
    PhotonNetwork.JoinLobby();

}
```

The above methods will be executed one after another to establish a successful connection to the server. Once the player is connected to the server it will join the lobby before joining the room. In Photon PUN “lobby” and “room” are concepts used to manage and organize multiplayer game sessions, facilitating how players join and interact with each other in a networked game environment. A lobby in Photon PUN is a central place where players can gather before joining a specific game room. A room in Photon PUN is where the actual multiplayer game takes place. Rooms are instances of the game that players join to play together. Each room has its own isolated environment, separate from other rooms, ensuring that interactions and gameplay within one room do not affect those in another. Once the player has join the lobby the `“RoomUI”` gameobject will be set enabled. The `RoomUI` game object is the collection of UI elements responsible for taking player’s nick name and room initialization script.

In the current prototype I am using only one room that is why in the user interface there is no option to choose from the room list. The following code snippet will take the player’s name from the input field and attached it to the Photon PUN native player Nickname property.

```
0 references
public void InitiliazeRoom(int defaultRoomIndex)
{

    // Set the player's nickname from the input field right before connecting.
    if (!string.IsNullOrEmpty(playerNickName.text))
    {
        PhotonNetwork.NickName = playerNickName.text;
    }
    else
    {
        PhotonNetwork.NickName = "DefaultName"; // Set a default name if no input is provi
    }
     DefaultRoom roomSettings = defaultRooms[defaultRoomIndex];
    RoomOptions roomOptions = new RoomOptions();
    roomOptions.MaxPlayers = (byte)roomSettings.maxPlayer;
    roomOptions.IsVisible = true;
    roomOptions.IsOpen = true;
    PhotonNetwork.JoinOrCreateRoom(roomSettings.Name, roomOptions, TypedLobby.Default);
    PhotonNetwork.LoadLevel(roomSettings.sceneIndex);
}
```

Synchronizing data

After the player has joined the room, they can start exploring the physical space to collect coins. Players can tap their phone screen to collect coins. This prototype uses RaycastHit method in the Unity Update function to detect taps. If the tap is on one of the collectable the `CollectCoin()` function will be executed to update the coin count number for the local player and broadcast the unique name of the coin through RPC method. The RPC (Remote Procedural Call) method will ensure that the tapped coined is disabled in every game instance across network. The same RPC method will update the coin count number of each player calculating the remaining count and the highest count to declare the winner.

User Experience Limitation of multiplayer AR Games

The interface of multi player AR games takes on new dimension. In the non-immersive screen-based games for example conventional video games played on phone and on a computer screen where the game environment is completely virtual the representation of multi player aspect is fairly straight forward. To represent the playing individual and other players in conventional video games, a virtual persona of the player is used to represent player actions. These virtual personas embody and represent all actions that human players are taking. Each player is aware of the actions taken by the other participating players through the virtual personas of participating players. for example, if, subjective I, the host players want to see the actions of another players I can look at the digital persona of the other player. However, in the AR game the digital persona of a player does not exist. Digital personas are needed for the virtual world however in the multi player AR games the physical body is player persona. But the player actions in the AR world are both physical and digital. For example, moving in the space is a physical action which other co-located players can see but shooting at a digital object in an augmented world which other players can see requires further exploration of action visualization. In the conventional non-immersive screen-based games the visualization of actions taken by other players are represented through virtual effects for example shooting action has a virtual effect of a glowing spot anchored from the virtual persona of the player. However, the visualization of action taken by other participants is a complex and unexplored area as physically co-located AR experiences do not have virtual personas of self and other participants. On way potential way of doing this is to anchor virtual effects from the physical body of the other co-located participating players but this technique requires a continuous sense making of special meta data and object identification including position, posture, gesture of all co-located players. However, today's AR technology lack this level of sophistication. In this prototype, the sound effect upon collecting a coin coming from the players who collected the coin inadvertently add a user experience aspect of signaling other co-located players that an action has occurred. Furthermore, the specific coin's disappearance from all instances of the game also offers a visual cue.