DESIGNING A REALITY-AWARE AUGMENTED REALITY

Affording enjoyable experiences for the fans of golf by transferring The sport’s physical game properties to augmented reality challenges

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Interaction design
Master Level, Two-year master
15hp
Semester 2 / 2019
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ABSTRACT

This article shows the process followed to analyze the game properties of golf, separate them into mechanics, dynamics and aesthetics in order to transfer these to an AR game. The goal of this is to have a human-centered approach having golf fans participating in every stage of the process to achieve the goal of creating enjoyable experiences for them. To do this, enjoyment is studied from the perspective of psychology as a response to the need satisfaction experience and from the point of view of game design, analyzing the role of enjoyment in ludic and paideic experiences and how enjoyment can be the main experiential goal of a autotelic experience or a secondary one in exotelic experiences. Finally this project follows the design of the AR game and shows the results of the procedure.
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1. OUTLINE

1.1 INTRODUCTION

Augmented reality (AR) is a technology that is redefining the limits between the digital realm and the physical one. It is reshaping the world around us and creating new opportunities for experiences and interactions that were only possible in science fiction. Even though the concept of augmented reality is not a new one, the idea of adding computer-generated graphics to the real world to enhance experiences has been around for a long time, but it’s thanks to the advances in processing power in smart devices, multi-sensor tracking, and data transfer speeds that the conditions have been met for the dawn of accessible AR experiences. The new technical possibilities has also boosted the development of better virtual reality (VR) experiences, a virtualization technology that like AR allows users to interact with digital graphics but with a different approach. To understand the differences between them it is necessary to explore the definition of each one of these terms. The Oxford Dictionary defines AR and VR in the following terms:

- Virtual Reality: The computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.

- Augmented Reality: A technology that superimposes a computer-generated image on a user’s view of the real world, thus providing a composite view.

Both virtualization technologies open the door to vast playgrounds for the interaction design field. On one side of the spectrum, VR immerses users into virtual worlds completely disconnecting them from the real world, while AR technologies enhance the real world by bringing the virtual objects and graphics into it, allowing for an infinite amount of possibilities for reimagining how normal tasks are performed and how real spaces are used. There are two main reasons why the later (AR) has been more attractive for interaction design researchers.

The first being the accessibility to the equipment needed for enabling both experiences; whereas VR hardware is considerably expensive to acquire and cumbersome to carry, the AR hardware is already in the pockets of approximately 43% percent of the human population (GSMA, 2018). The adoption of smartphones and tablets has granted users with a reliable and portable AR-enabled device without any upfront costs for hardware.
The second reason is the wider range of possible applications, while VR has been a reliable tool for entertainment, education, and space exploration by creating completely immersive simulations (Wexelblat, 2014), its applications are limited to virtual worlds. AR has proven to be a more versatile tool in a wider range of areas (Aukstakalnis, 2016) because it breaks through the limitations of VR of isolating the users away from the real world. AR offers to create both purely virtual experiences, supporting physical tasks or enabling physical objects and digital ones to be part of the same experience (Sony, 2018).

The unique qualities of enhancing physical and cognitive tasks in almost any industry make AR a promising tool for interaction design, a field which intends to “support the way people communicate and interact in their day to day and working life” (Preece, Rogers, & Sharp, 2015, p. 21). In addition to the definition of Interaction Design given by the authors Preece, Rogers, & Sharp, they repeatedly mention the criteria that separates a good design from a poor one, and that is making the design usable and enjoyable. While AR experiences fulfill the aforementioned criteria, it resonates more with the last one, enjoyment, making it a reliable candidate for game design (Tan & Soh, 2010), autotelic experiences that seek to afford enjoyment (Deterding, 2015) where there’s no design purpose other than the experience itself, and the design of serious games. As useful as AR is for designing gameful experiences it must look outside the digital realm to better simulate ludic activities in the real world.

To design AR experiences that afford enjoyment it’s necessary to explore beyond digital games, into activities that have been the main source of enjoyable experiences for centuries, sports. With billions of fans worldwide and existing since the dawn of ancient civilizations sports are without a doubt one of the biggest sources of entertainment in the world, both for the players (casual or professional) and for the spectators. The existence of physical and digital games drives its fans to compare them, creating rivalries between the two ways of experiencing games. Each one has its own strengths and weaknesses, most of the times one shines in an area where the other one doesn’t, like the ability to play digital games everywhere or how sports allow for diverse challenges beyond a game controller or touchscreen. It is in the midst of this rivalry that augmented reality shows promise as it focuses on designing experiences for the physical world through the lenses of a digital device, which means merging the digital objects with real objects and spaces.

Even though sports have been recreated countless times in video games, AR allows for experience grounded in the physical world and therefore can do a better job at embodying the dynamics of physical challenges in order to face the players with tasks that will motivate them and ultimately afford enjoyment by satisfying the psychological needs of autonomy, relatedness and competence (Deci & Ryan, 2000) just as it happens when they participate in the sport.
This thesis research focuses on using AR technologies as a bridge between the physical and digital experiences, aiming to design interactions and game challenges for sports fans by analyzing the physicality of the sport, the interactions and challenges involved in it to reimagine them as mechanics, dynamics and aesthetics in a digital experience that affords the same type of enjoyment experienced in the physical activity. The sport selected for a practical application was golf and this project reports on the research, design and prototyping of an augmented reality experience for the golf fans engaged with the professional tournament “Scandinavian Invitation” in Gothenburg, Sweden.

1.2 Research Questions

How transferring the physical game properties of golf to augmented reality challenges can afford enjoyable experiences for the fans of the sport.

1.3 Ethical Concerns

This project was developed in collaboration with IBM for creating new ways for golf fans to interact with the sport and live events while being physically present and at a distance. The project and design decisions were made for the sole purpose of impacting the fan experience in a positive way, avoiding making decisions based on the benefit of the business, organizers and sponsors.

Collaboration from the IBM team, users, and event attendees was voluntary, and they were notified that this work will be published. Names and information of the people who participated in interviews and user testing will be protected and not shared in this report as stated in the participation agreement. First names, photographic and video records that appear in this work were reviewed and approved for publishing by the subjects appearing in them.
2. BACKGROUND & THEORY

2.1 The project, stakeholders, and end users

The project presented started as a study of methods to transfer the enjoyment afforded from physical activities related to fan experiences, into augmented reality experiences. To accomplish this goal, an alliance with the company IBM was established, since they were interested in researching new ways to engage golf fans with live tournaments like the Scandinavian Invitation. The idea of using AR to create an experience for golf fans that affords enjoyment based on analyzing the physicality of the game’s properties was very appealing to the stakeholders. IBM, the event organizers and sponsors wanted to reach the attendees of the live event as well as the fans experiencing the event at a distance, and provide them with new ways to enjoy the event through a digital experience that would be accessed through their phones and the dedicated app developed for the event. To make it clearer, the end users are meant to be the golf fans attending these tournaments or expecting from their homes, not the professional contestants of the event, and the stakeholders aided the project by facilitating the connection with fans, to make sure they were kept involved in each stage of the project.

The project then started with a clear picture of the materials it would use and that it would exist as an experience for smartphones, what was not clear and was discovered through the project is what type of experience it would be. There are many options with AR experiences, as this technology allows for a wide range of applications, both instrumental tools for accomplishing tasks in a playful way or creating gameful experiences with the unique experiential goal of participating in the experience.

2.2 Interaction design and enjoyment

Enjoyment is an integral part of interaction design, and serves as a measuring factor that usually determines the success of the user experience. As stated by Preece, Rogers, & Sharp (2015) when discussing good and poor design, enjoyment is the outcome of a good user experience, opposite to frustration. “Usability refers to ensuring that interactive products are easy to learn, effective to use, and enjoyable from the user's perspective.” (Preece, Rogers, & Sharp, 2015, p. 30). The authors repeatedly portray how enjoyment fits in the user experience of using a product, but this definition is limited to cases when users interact with an object to complete a task, making the interface just an intermediary between the user and the goal. Csikszentmihalyi (1990) offers a broader look at the relation between users and goals by separating the interactions between autotelic and exotelic. Interactions with an exotelic purpose
are when users interact with an object or interface in order to achieve something outside the interaction itself, for example, the act of operating a light switch in order to turn on a lightbulb. In the use case described, enjoyment is experienced as a byproduct of the successful completion of the task, given that the experience was effortless, effective and the interface was aesthetically pleasing. On the opposite side of use cases are tasks with an autotelic purpose, self contained experiences performed for the fun of doing them, just like playing a game of golf. In this case having “fun” is not a byproduct of the completion but the main goal of the whole experience. Having enjoyment as the main goal of an experience requires to have a deeper understanding of the concept and this research will base it on previous research from the fields of psychology and game design.

2.3 Understanding enjoyment as the experience of need satisfaction

As the main goal of this thesis, affording enjoyment must be defined for this project in terms that can be understood without any ambiguity and psychology offers a clear model that has been widely used on interaction design and game design research (Deterding, 2015). The self-determination theory (SDT;Deci & Ryan, 2000) explains how the feeling of enjoyment is the result of the satisfaction of three basic psychological needs, autonomy, relatedness and competence (ARC). “autonomy, the experience of acting with volition and willingness, in congruence with one’s own goals, needs, values, and identity; competence, the experience of one’s (growing) ability to achieve desired change in the world; and relatedness, a sense of intimate connection with others.” (Deterding, 2015, p. 298). Although this theory establishes a solid foundation to how golf players can have an enjoyable experience, the authors Przybylski, Rigby, & Ryan (2010) used the SDT to form a framework that accounts for the experience of fun and motivation in games, the player experience of need satisfaction (PENS) model (Przybylski, Rigby, & Ryan, 2010). The PENS model explains how players partake on games in order to satisfy one of the innate psychological ARC needs, either by spontaneous interest based on previous experiences or the extended deprivation of one or various of the ARC needs (Deterding, 2015). Now that the relation between player need satisfaction and enjoyment has been established the next question is how exactly do games like golf satisfy those needs. The answer to this question is found on the main mechanism that game design uses to satisfy the needs of autonomy, relatedness and competence are challenges.
2.4 Challenges in Interaction Design Vs Game Design

While the whole purpose of interaction design is to make tasks effortless and remove any challenges between the user and the goal (Preece, Rogers, & Sharp, 2015), while game design focuses on creating challenges for the players in order to achieve the goal. Sebastian Deterding highlights how this logic might conflict with the field of interaction design by saying “As Cook (2008) put it, if a usability engineer were to redesign Super Mario Bros. with the sole goal of usability, the result would be a single button, labeled “Rescue Princess.” By easing the avowed instrumental goal into a single button click, the actual experiential goal of enjoyment is destroyed.” (Deterding, 2015, p. 303). This statement shines some light on a fundamental difference, which is the experiential and instrumental goal. As described in the example of the light switch, turning on the light is the instrumental goal while the experiential goal is the user experience of the light switch. In the case of games, enjoyment is the experiential goal, which is achieved by completing instrumental game goals, in this case, saving the princess. Other games don’t even have an instrumental goal, like the game Tetris, in which there’s no end other than postponing the inevitable moment when the player loses, the “fun” is in the experiential goal of postponing the end of the game for as long as possible. “Most common definitions of games agree that a game consists of one or more interconnected challenges a player is trying to overcome, which emerge from the player taking actions in pursuit of goals, and rules and objects/opponents that make attaining those goals challenging” (Deterding, 2015, p. 299). In contrast to Interaction design, game design creates challenges, obstacles and rules that distance the player from the goal they are set to achieve, and that is where the enjoyment lays.

2.5 Challenges as the main way to affect motivation and enjoyment

Challenges are the single most important part of any game, and these afford enjoyment and motivation by satisfying the player’s psychological needs and Deterding (2015) explains the five different routes to achieve this or types of challenges: (1) satisfying autonomy by letting players choose to take on the challenges, in which way and in which order. (2) satisfying competence by completing non-trivial challenges that puts certain players skills to a test. (3) satisfying relatedness by completing challenges with others, against others or for others, including digital characters. (4) satisfying curiosity by allowing players to take on challenges with uncertain outcomes (5) avoiding unpleasant thoughts by blinding attention and cognition with challenges.

The designer are burdened with the task of charting the path for the project and recognizing which challenge routes will lead to the motivation and enjoyment of a specific group of users, by
mixing, matching and graduating the difficulty. In the words of Fullerton, games are meant to “challenge the players by forcing them to employ a particular skill or range of skills. The procedures also create a sense of competition or play, which is enjoyable in some way, so that players will submit themselves to this inefficient system to gain the ultimate sense of achievement that comes from participating.” (Fullerton, 2008, p. 77), and continues to define challenges as “tasks that are satisfying to complete, that require just the right amount of work to create a sense of accomplishment and enjoyment” (Fullerton, 2008, p. 86). Therefore, more than adding arbitrary challenges, game design is about adding the right challenges in order to affect the players by displaying challenges that will resonate with the player’s skills and with the right level of difficulty, which will motivate them to engage with the game and submerge in a cycle of challenge motivation and need satisfaction.

The theory described helps to make sense of why the users seek enjoyable experiences, and continuous engagement with the experience grants them the rank of fans. Nonetheless, there’s more that game theory has to offer to understand the engagement with the golf events, since this is a space where players attend to be engaged with the sport, but not by acting as players. To have the theoretical basis to understand different ways of game engagement is necessary to expand on the two different modes of play.

![Figure 1. Illustration of the process to to satisfy the need of enjoyment. By Daniel Velasquez](image-url)
2.6 Modes of play: gameful and playful experiences

Analyzing enjoyable experiences from the perspective of structured games with clear rules and challenges only covers half of the spectrum of play. The duality of the modes of play is analyzed in the book “The gameful world” by explaining that “all forms of human play fall on a spectrum between open, free, exploratory play as we find it in children’s object and pretend play (paidia) and formalized, rule-based, goal-oriented play as we find it in games (ludus).” (Watz & Deterding, 2015, p. 7). Therefore, when placing the experience of playing golf on this scale, it ends up in the side of ludic play, because of its clear structure and clear goal to overcome the challenges within a set of clear rules. On the other side of the scale is the concept of paidia, the curiosity-driven play that is explorative and unstructured, meaning there’s no starting point, steps or a clear goal different than enjoying the exploration.

Figure 2.1. Graph taken from “The gameful world” (Walz & Deterding, 2015)
To expand on the binary idea of having a serious game or a serious playful experience, Deterding offers another dimension to differentiate between complete and partial applications of the modes of play into a given experience. There are cases in which an experience wants to include qualities or elements of either paidic or ludic play, and by doing this the experience can be qualified as a playful or gameful design.

Understanding the concepts of the modes of play and having the criteria to identify and qualify enjoyable experiences will allow this project to understand two different pathways to enjoyment in terms of the game experience. Further research will help to establish how eager are the fans to participate in events with different activities that relate to the game, either by watching professional players compete or other activities either playful or gameful that fall under the umbrella of the golf theme in some measure. This theory will aid in the ideation and prototyping as a compass to keep the nature of the project oriented by the modes of play and mapping every design proposed inside the game design spectrum.

2.7 Game properties: the MDA framework

In hopes to create a clear model that tackles the chained elements that constitute a game experience, Hunicke, LeBlanc, and Zubek, (2004) presented the mechanics, dynamics and aesthetics framework (MDA). “Fundamental to this framework is the idea that games are more like artifacts than media. By this we mean that the content of a game is its behavior. not the media that streams out of it towards the player.” (Hunicke, LeBlanc, & Zubek, 2004, p. 2). Thinking of games as artifacts gives it interactive characteristics that other types of media do not have, it’s very different to watch a story in a movie than playing a story in a game. Games can have an unpredictable and unstructured nature when they are in the hands of the players, because even if the game has a clear path or story to follow, it is up to the player to decide at which pace and some times in what order they want to experience it.
Figure 2.2. Illustration of how the MDA properties interact with each other

The mechanics are the actions a player can take, like in the video game of Tetris, players can move the Tetrominos (Tetris blocks) horizontally, and rotate them until they reach an optimal orientation to connect with the surface at the bottom of the screen. At the same time the mechanics are also what can happen in the game world or how it responds to the players actions; following the same example of Tetris, the Tetrominos are constantly falling, and as time passes the fall speed increases.

The dynamic are the systems created from the patterns imposed by the mechanics, like the constant pressure in the game of Tetris and how the tension increases as the game is prolonged by the increased speed of the blocks, because the repeating mechanics have influenced the gameplay and created game systems.

Finally, these ongoing dynamics lead to establishing aesthetics, which are the emotions inspired in the players from these systems, creating different types of enjoyable experiences. When Tetris players encounter the Tetromino dynamics, it generates the feelings like focused-play and rewards rapid thinking, concentration and adaptability.

Each one of the MDA elements triggers the next one, and that’s what makes this model so useful, it links seamlessly the interaction design of the mechanics with the enjoyment and emotional engagement of the players. This model allows the designers to plan the desired experience or aesthetics they want the players to experience and then design the mechanics that will ultimately generate that feeling.
2.8 Canonical Examples

2.8.1 Heads-Up Display

Steve Aukstakalnis (2016) does a great job highlighting all the advantages and applications of augmented reality from its beginnings. One of the most relevant references is the heads-up display (HUD) created for the aviation history as an example of how data visualization can be integrated by superimpose graphics over the real world in real time to enhance and facilitate the experience of piloting a plane.

The main reason that makes this project a reference for this research is the fact that this is one of the precursors of many modern tools and the technology that inspired countless science fiction devices. The HUD came to be from the sheer need of simplifying a convoluted and saturated interface, as aircrafts and helicopters were becoming so complex that the controllers, panels and devices they had to analyze and operate was taking all of the pilot’s attention and becoming such an obstacle that pilots were not aware of what was happening outside the aircraft, often resulting in tragic accidents.
Thanks to the tireless efforts of scientists and engineers the Heads-Up Display was created. “Following the development of the airborne electronic analog computer in the 1950s, these research efforts resulted in the introduction of the first modern head-up (or heads-up) display (HUDs), a transparent display mounted in front of the pilot that enables viewing with the head positioned “up” and looking forward, instead of angled down, looking at instruments lower in the cockpit. Because the information projected onto the HUD is collimated (parallel light rays) and focused on infinity, the pilot’s eyes do not need to refocus to view the scene beyond the display outside of the aircraft.” (Aukstakalnis, 2016, p. 4). The device allowed the pilots to visualize critical information of the aircraft, weaponry and receive communication without taking their eyes from the horizon.

This type of displays evolved into different technologies today, among them how smartphones and tablets try to replicate this functionality by acting as a translucent glass that overlays 3D models and information over the spaces of objects that people need to interact with. Just like the HUD, AR users can perform tasks without taking their eyes of the object they are working with.

These types of augmented displays create playful experiences that not only provides additional information to the users but makes the task more interesting and engaging.

2.8.2 Pokémon Go

When Niantic brought the Pokémon augmented reality game to the smartphone marketplace, it was very well received by its audience. “Pokémon GO was initially released in July 6, 2016, then its company earned $500 million in 63 days. In August 2016, Pokémon GO accounted for 28% of the US mobile games market.” (Mayuri, Nikita, Bharat, Vaishnavi, & Gaike, 2017, p. 134). The successful release was mainly aimed to nostalgic fans of the Pokémon TV series that aired in the 90’s, making this project a great case study of how to engage fans with experiences that bearing the theme and attributes of the subject they are so passionate about. The fans were not the only ones astonished by the new experience it offered, but game designers and interaction designers as well, not only because of its success or the implementation of AR into a full game, but because it managed to gamify the simple act of walking. The biggest implications of this were in the area of serious games; these are games that along with the experiential goal on affording enjoyment have an instrumental goal, these are usually educational goals, training goals, or attempts to make workspaces more engaging. To understand how Pokemon Go successfully gamified walking here’s an overview of the game.
The game is quite simple, it consists of an interface similar to Google Maps that displays the player location in the real world, the difference is that Pokémon will appear on the map and the players have to move or walk in the real world to get close enough to the little monsters to be able to interact with them and activate an encounter. Once the encounter is active, the game screen changes from the map view to the encounter view, the camera is activated, and a 3D render of a Pokémon is tracked to the real space that the players see on their screens. At this point the players play a dexterity game where they have to throw Poke balls at the monsters, and on a successful hit, the Poke ball will attempt to catch its target. The goal of the game is to “catch ‘em all”, to complete a list of over 150 Pokémon in a set-collection game, but further updates to the game doubled and then tripled the headcount of Pokémon, added battle mechanics for area control dynamics and trading among players.

Another compelling argument to study the Pokémon Go case is the fact that the game relies on using augmented reality to bring pocket monsters into the real world, giving a new dimension to the game. This feature added a playful element to the game, as players would explore the real world and see it with new eyes, as well as witness how familiar spaces look when inhabited by Pokémon. As a result of these monsters living in the real world, some terrains will favor the spawning of specific types of Pokémon. Water type creatures will appear next to rivers, beaches and lakes, while stone and ground types will find more arid terrains more appealing to inhabit. This means that if a player wants to catch a specific type of Pokémon, then that player will need to travel to a location that shares the monster’s affinity.

![Figure 4. Illustration of how real-time weather affects the gameplay (From Pokemon Go App, Gampley screenshots)](image)

In addition to the previous points that make this game a relevant reference for this project is the way in which it connects to the real world on real-time. The game brings the monsters into the
real world using augmented reality, but it doesn’t stop there. There are other ways in which it directs players into interacting with real spaces, the first one is the concept of PokeStops, landmarks that the players must physically walk to so they can activate them and gain more in-game consumable items. Second, the real-time events happening in the game called “raids”, which tell players that a specific time in a specific place and event is happening. These events have gathered hundreds of players in the same location to the point of even crashing the game servers at a point. Third, the real-time weather recognition of the game has mechanic implications in the gameplay, as the Pokémon that are likely to spawn in a given area are impacting by the weather conditions. For example, if it’s raining then water type monsters will appear, and the game will display graphically rain conditions in the game map.

2.8.3 Angry Birds AR

![Figure 5. Promotional image of Angry Birds AR (From https://www.rovio.com/)](image)

The game Angry Birds AR is a new iteration of the classic mobile game, where once started, the game prompts user to find a suitable surface to play by opening up the camera and using it to transform the screen into a clear glass that allows to see the space they inhabit. Once the surface is selected, a whole island appears on it, it can be explored in 360 degrees by walking around the surface and looking at it through the smartphone. The game takes much from its predecessor when it comes to gameplay, but adding a third dimension ads a layer of
playfulness to the experience that it did not have before. Instead of being a two-dimensional (2D) puzzle, the game now allows players to solve the puzzle of striking down all the enemies by throwing no more than 3 birds at them by exploring the space in 3D and choosing which angle is the best one for taking a shot.

This game explores a gameful design that adds playful elements to refresh an already familiar experience to players. The rules and mechanics are basically the same but when reimagined for AR gameplay end up creating new obstacles that build on top of the already existing challenges to motivate players into coming back to the game. The idea of refreshing an experience by presenting it in a different way can be applicable to golf fans, which can be done by taking a closer look at the already existing challenges and and look for ways in which AR can build on top of them instead of cluttering and destroying the experience they are already fond of.

### 2.8.4 A(i)R Hockey by Sony

![Figure 6. Photo of the A(i)R Hockey game by Sony Corporation at SXSW 2018](https://www.sony.net/SonyInfo/design/stories/AiRhockey/)

South by SouthWest (SXSW) is one of the biggest interaction design conventions in the world where the biggest brands and the independent developers gather to showcase their innovative projects and their concepts for the close and distant future. On 2018 Sony did just that, by bringing its interactive playground to the event, “The Sony Wow Factory”, which had diverse catalog of experiences, from sound, virtual reality to augmented mazes. One of the games they showcased stood out and became a subject of study for this particular research, and that was the A(i)R Hockey, a game that mixed physical objects that interacted with digital game components.

At first glance the game looked like a circular air hockey table, with 3 classic plastic pushers used to hit the hockey pucks, but the pucks themselves where nowhere to be found. Once any
potential players approached the table, projectors from the ceiling would light up the table and display the goal line for each player as well as the digital hockey pucks projected in the table. Thanks to an array of sensors tracking the movement of the pushers the projected pucks would perfectly interact with the pushers by calculating the speed and direction and simulate the collisions and eject the puck in the desired direction. Even though it lacked the haptic feedback of the collision, there was a visual and acoustic feedback, and it brought new unexpected possibilities to the game. There were new challenges, like adding additional projected pucks on specific events, adding physical pucks that would interact with the digital ones and the mechanic of having the pucks change color once a player hits them to determine who gets the points if it enters another player’s goal area.

2.8.5 Canonical examples conclusion

The canonical examples explored show the evolution of augmented reality experiences and how this tool can offer a wide range of solutions. One of the best examples is the HUD, a technology created decades ago that still impacts AR experiences and science fiction until today, the promise of a glass that lets us enhance reality by displaying real-time information based on the context the users are in. Even smartphones today try to live up to this promise with AR tools and mobile games.

The games analyzed show the colossal potential for game design and for creating new experiences that work on top of existing games to deliver a new sense of discovery, exploration and motivate players with new challenges. Even in the realm of games AR is very versatile, allowing designers to create experience anywhere in the spectrum of the modes of play, making them playful, gameful or creating experiences that are somewhere in the middle or making gameful experiences with playful elements. Pokemon Go also shows the success of gamification, allowing for serious games that genuinely afford enjoyment but at the same time have an instrumental goal to enhance something in the life of the player.

Finally, the A(i)R Hockey game by Sony breaks any barriers between digital and physical games by creating a glass-free experience that lets physical objects interact with digital ones, and those same digital ones also significantly enhance the player interface and user experience.

Each project provides answers to questions about augmented reality and shows its potential, but at the same time raises the question of how can this be applied in other areas. Even if these projects do not offer a clear template to follow to create successful games or AR tools they offer insights on how to create them.
3. METHODS

3.1 Double Diamond

Affording enjoyment for golf fans is a goal that comes with many challenges to overcome, but in order to do so there needs to be a clear structure for the design process. The first step is to draw a clear path for the design work is to use the double diamond model to have clearly defined stages and manage time more efficiently. The four stages of this design process, Discover, Define, Develop and Deliver, grant the right balance for an explorative creative process. Shifting from divergent thinking in the open ideation stages to a convergent thinking when distilling the existing design possibilities is an effective way to approach unknown subjects and audiences. This is the case with the golf fans and the experience they have in the live events, where there’s a need to deeply understand the context, audience, and what conforms the fan experience. Understanding all the components will allow to assess the current state of the fan experience and to determine what the fans enjoy from it, which will be the criteria to narrow down the ideation towards the desired aesthetics that the experience should inspire.

3.1.1 Discover

This step is going to be crucial, as embarking on a project involving such a passionate fanbase requires thorough research to be able to communicate with fans sharing common knowledge about the sport and events. The sports communities can have two different roles, being both players and spectators, making the information they can provide extremely valuable. As the objective is to create enjoyable experiences for fans it is important to consider different research methods to understand the sport and tournaments themselves, this can be achieved with observation, data gathering and benchmarking the different existent golf events. As attending the events themselves will not be an option for this research, this exploration will be done by analyzing existing content, articles, photos and videos of previous events. This initial investigation is just the initial step of the discovery phase, to be followed by approaching the fans and event attendees in order to have open discussions that will nurture the idea of enjoyment for the fans while staying in a divergent mindset.

3.1.2 Define

The success of this process will be in selecting a design proposal that hits all the right notes and harmonically balances the experience goals for the golf fans at the live events, at their homes
and other spaces. Additionally, understanding how to challenge the users in a way that affects them to motivate them to partake in the experience. Another parameter is the time limit, as the solution created will be shared with the organizers of golf events.

To accomplish the goal of finding the right design, the main tools will be structured interviews and human-centered and playcentric methods with representatives from these parties, using these to validate the concepts and the potential experience for fans. Further iterative ideation will take place based on the feedback, until a solution is framed.

3.1.3 Develop

The development of the project starts with the clear framing of the problem and is the part of the process where the right design, one that embodies all the characteristics of the objective, is selected. With this direction selected, there are many ways in which a specific project can be crafted, but the challenges and experiential goal must reflect the experience of enjoyment the users get from the sport. The final deliverable for the event must be something accessible through the official mobile application for the fans or be an accessible solution.

The digital material that will be explored will make use of augmented digital tools, therefore in this stage this implementation will be explored along with the range of possibilities this can offer, from playful data visualization to more ludic experiences. In this stage these questions must be answered in order to start the playcentric iterative process.

3.1.4 Deliver

In the last stage of this design process is the delivery of the final product. In this project that means to have a completed version of the design and aesthetics to evoke, which will serve as a proof of concept for AR experience based on real-world insights. To achieve this, there will be an iterative process, where prototypes will be validated with the final users. Fast iteration and gathering feedback are the top priority, which is why physical elements will be used to emulate the 3D graphics that would be seen through the AR interface. Using these low-fi physical prototypes will allow to validate how the 3D graphics will look and feel, as well as how they will interact with the real world. Following this, digital prototypes will be used for the interface and creating any elements needed to deliver a complete experience.
3.2 Human design before design

This concept proposed by Jens Pedersen, “design before design” (2015) was thought for codesign, a concept that covers all the preparations that must be planned before the actual research happens, which might seem as all the project management tasks needed for a codesign workshop. “By design before design, I mean those preparatory activities where the ‘actual’ design activities are designed. ‘Before’ should not be understood temporally, but ‘transcendently’. It is the creation of the conditions for the possibility of doing codesign, so to speak.” (Pedersen, 2015, p. 3) This concept seems applicable to most scenarios when the researchers need to contact a company in order to arrange a workshop. There are other scenarios that must be accounted for, like contacting individuals, where the logistics to connect with the users for interviews and workshops are not enough. In order to establish a successful communication when reaching out to the final users, what is needed is to connect with their passion and motivate them to engage in the discussion, identifying the value of every bit of information they provide. In the case of this project, connecting with sports fans requires to understand them and their subculture.

The way to accomplish these communicational goals is by adding a human layer to the “Design Before Design” (Pedersen, 2015) to communicate effectively with the users, which needs to be carefully prepared before establishing the communication itself. Every niche builds its own subculture, and with it comes a set of semiotic codes that need to be deciphered. Approaching them without a common ground would mean researchers could potentially neglect important parts of the communication or miss out on valuable insights. From the point of view of the users, they might not feel they are talking to a valid interlocutor, someone who understands their passion. This lack of resonance could lead to users not being completely open or as engaged in the discussion as they would be with someone who shares the empathic bond to the subject they feel so strongly about.

3.3 Human-centered design research

When setting design mindset for the project, there are many places to draw inspiration from as many methods offer their own set of tools customized to reach the objectives. There is one that fit the bill in several points, as it has the creative flexibility to allow for divergent thinking and convergent explorations of the information gathered, IDEO’s “Field Guide to Human-centered Design” (2015). This mindset encourages optimist investigation, giving the researchers the tools and methods to embark into the unknown and come out with valuable insights from unexpected places. The key focus is in the users and establishing a connection with them based on
empathy with the users, spaces and embracing the fact that designer don’t know where they are headed, there’s no clear answer or solution but by following the steps of inspiration, ideation and implementation of a solution will be reached, through iterative cycles with simple prototypes that help materialize ideas in order to present them as something real to the human target audience to get their feedback. This method brings benefits for the initial stages of the double diamond process, helping structure the discovery and definition while the design and prototyping will rely more on a playcentric design method.

3.4 Playcentric design

The playcentric design method explained by Tracy Fullerton (2014) is an iterative experiential design process in which the designers define the aesthetics they want to evoke on the players when they play a game. This means bringing players to actively participate in the project as soon as possible, something that completely connects with the human-centered design approach, allowing this research to enrich the design process from the synergy of the methods, as this method will be more useful for the later stages of design and prototyping.

![Diagram](image)

*Figure 7. Illustration playcentric method by Tracy Fullerton (From Fullerton, 2014)*

The playcentric method was used directly relating it to the MDA model, where the aesthetics signify the experience the players will have when playing a game. The playcentric method focuses on envisioning the aesthetics and then ideate and design the mechanics that will trigger
such result. Just as explained in the MDA theory the mechanics will work together to create a system and along with the player’s interactions with the system will generate the aesthetic. Fullerton calls these “experience goals” and shares a few examples of what they can be, for example “players will have to cooperate to win, but the game will be structured so they can never trust each other,”, “players will feel a sense of happiness and playfulness rather than competitiveness,” or “players will have the freedom to pursue the goals of the game in any order they choose.” (Fullerton, 2014, p. 11).

When designing mechanics for a specific aesthetic, the outcome is uncertain which leads to an iterative process of testing mechanics, the dynamics they develop and the aesthetic and the sum of these as the experience goal. The cycle involves testing gameplay, evaluating, ideating on possible solutions, implementing the solutions. This is repeated until the desired experience goal is met.

3.5 Interviews

One of the methods detailed are interviews, and among the different types the field guide offers there’s a distinction of interviews for users and for experts. This is where this research will find a middle point, by taking the participatory consideration of regarding the “people as the true experts in domains of experience such as living, learning, working, etc.” (Sanders & Stappers, 2012), in this case the fans are experts at being fans and no other figure could know more about their perspective or the knowledge of their subculture.

To start the research phase, the users will be approached for unstructured interviews, which will be composed of open questions to spark discussions and branch out into other possible questions that go toward the objective of understanding the experience from the point of view of the fans and understand how they experience “fun” while engaging with golf. “A benefit of unstructured interviews is that they generate rich data that is often interrelated and complex, i.e. data that gives a deep understanding of the topic. In addition, interviewees may mention issues that the interviewer has not considered.” (Preece, Rogers, & Sharp, 2015). There are clear benefits to open the research using this type of interviews and as stated in the citation, the most promising one is the unexpected, all the things researchers are not even considering that might be brought to light thanks to this method. This process is going to help understand what the research should focus on when moving towards other methods of research.
3.6 Secondary Research

Although there’s a lot of information that can be learned from traditional observational methods, like shadowing or undercover inspection, there’s also the need to build a stable contextual bases to understand the information that is being gathered. IDEO’s Secondary Research method (2015) acknowledges this and lays down the steps needed to gather this information from publications, news, journalistic publications and official online sources. It’s important to understand the current state of the industry, latest innovations and pre-existing works. Evaluating how the same situation has been approached in the past is going to benchmark the ideas and generate new insights.

3.7 Physical Prototypes

Inspired by the work of Tracy Fullerton the first prototype iterations of this project will rely on using physical prototypes for digital games using her guidelines and trying to exploit all the benefits of this method. (Fullerton, 2014).

![Figure 8. Photo of a paper prototype of a first-person shooter video game (From Fullerton, 2014, p. 181).]
Using physical prototypes is the easiest and most inexpensive to construct without a whole development team. These will be built using paper, cardboard and easily obtainable items that will assure that these prototypes are fast, inexpensive and will be easy to modify in favor of testing mechanics and not wasting time on finished graphics. (Fullerton, 2014).

There are several benefits to this uncommitted method, starting with the idea of prototyping an AR experience while focusing on the gameplay and not on the technology. Augmented reality should mix seamlessly with the real world, and that’s why it makes perfect sense to test the experience in a physical form to understand how the experience should translate into a digital form. All of this must be done focusing on the gameplay and physicality before moving even writing the first line of code. Starting with the coding only makes it harder to make changes on the go, and this should be a priority when testing with users in participatory exercises, to be able to include their feedback, ideas or constructive criticism and go through several iterations in a short period of time.

This approach not only empowers users as decision makers, also the stakeholders and the design team members who are not versed in tech development. Having paper prototypes allows everyone to participate in the design process and share ideas without having any programming knowledge, ensuring a multidisciplinary collaboration in the design process. (Fullerton, 2014).

### 3.8 Playtesting Methods

The task of testing games can be very chaotic unless you have a clear path to do so, and this project consists of constant testing and designing the final experience together with the users in the form of workshops. Tracy Fullerton (2014) offers a method for playtesting that involve some parameters and tools to make the most out of each session.

When planning a playtest session, it should be a one-on-one session for a single player game or a group session for a multiplayer game. In the case of a one-on-one testing session the researcher will observe the players while playing the game, this can be done openly by watching over their shoulders as they play the game or discreetly by doing it over a one-way mirror. The important part is to document anything that happens by taking notes and asking questions about what they did and experience after the gameplay session.

The players should be encouraged to think out loud, they should be encouraged to explain every action they take, this will give some insights on the challenges they face, expectations, frustrations and evaluate gameplay affordances. While the testers are encouraged to talk the researcher must refrain from doing so, as one important parameter of the playtesting session is
not leading the players in any way. The testers should experience the game and the researchers should observe quietly without giving any directions. In the case of the tester asking questions, the researchers should reply by asking them “what do you think you should do?” and make a note of their answers. If the players reach a point in which they have no idea what to or renders the game unplayable, then the test has successfully identified something that needs to be fixed.

After the gameplay session, an option is to prepare a structured interview where the researcher sits face-to-face with the playtesters goes through some relevant questions that will give insights on the game design and allow them to compare it with other testers. Alternatively, the researcher can conduct an open discussion which can be one-on-one or in groups. The idea is to let the testers talk freely while the researcher might lead the discussion to in certain directions when it is necessary or introduce specific questions.

4. DESIGN PROCESS

4.1 DISCOVER

4.1.1 Planning and preliminary overview

The first stage of the design process was meant to gain enough knowledge of the sport, the tournament and the fans as possible, but before even starting there were some preliminary steps that needed to be taken. Following the learnings from Pedersen’s work of “design before design” (2015) it was crucial to research the sport in general by using online resources to understand the history, rules, equipment and build a simple glossary of terms that might come up later when conducting the interviews with the golf fans. Additionally, journalistic publications proved to be very useful to get up to speed on the latest golf events and the highlighted players for the season.

While online resources are useful, it was never the intention to be used as the actual source for the research of this project. The reason to use this channel was only to build common contextual basis between the researcher and the people who were to be interviewed. It is easy to waste a lot of the research time on the internet, but this becomes aimless search for answers, since the real object of study are the fans and how they experience enjoyment in the sport and it is from them where the answers will come from.
IBM and its contact network was very useful and allowed several golf fans who have attended diverse golf tournaments to be contacted and they agreed to participate in the interviews. As part of the preliminary preparation, each one was called by phone to verify their assistance, but the real purpose of the call was to ask two questions “What is your favorite golf events?” and “Who is your favorite player?”. This information, could have been part of the interview but having this information in advance allowed the interviewer to prepare better for the open discussions. A quick search was done to prepare some additional talking points for each interview.

4.1.2 Unstructured Interviews

The interviews were one-on-one discussion sessions with a total of 5 golf fans who are active golf players and have attended golf events. Each session consisted of seven questions separated into two discussion groups, the first one being questions about playing golf and the second one contained questions about golf events.

The goal of this exercise was to gain a deeper understanding of the dual state of being a golf fan, and understand how enjoyment is afforded by being an active player and by observing others play. The idea behind these questions was not to go through them in a specific order but to use them in each one of the discussions to spark other questions. The discussions included a tablet with internet access as a material, in case the fans wanted to share something or reference a website, photos or videos. In addition to the tools necessary to take notes.

4.1.3 Insights about playing golf

The main findings about the experience of playing golf were about the challenges the players face when playing golf, both physical and mental, as well as the main opponent they have to face. The physical challenge involves the mastery of using golf clubs to hit the ball, the main takeaway is that it is very hard. What makes it difficult is that players are actually interacting with the ball, the club must become an extension of their limbs. Just like toddlers struggle maneuvering their bodies in their early years, so do golf players with their clubs.

The mental challenge is in calculating the perfect shot, selecting the right club and analyzing all the factors before putting the mastery of the club to a test. Being a sport in which the players need to get the ball to the hole in the least amount of hits, golf demands concentration from the players before each hit, planning each swing like if it was a move in a game of chess. Analyzing the terrain and weather conditions is crucial, as well as the concentration to send the ball in the desired direction and plan the next moves in advance.
The main opponent when playing golf are not the other players, but the terrain itself. Golfers play against the field, the hills, trees, sand traps and water traps. Even the slightest inclination can change the outcome of a golf swing. The terrain contains all the obstacles that players must overcome making spatial awareness crucial.

4.1.4 Insights about attending a golf event

Golf fans not only enjoy playing, but watching the professional players compete in tournaments, but it turns out that when they attend the golf events, that's only one of many activities for them. One crucial finding to understand the experience of a golf fan attending a tournament is that unlike other sporting events, golf tournaments have a diverse selection of experiences for fans of the sport and their families.

A golf tournament consists of a group of professional players competing and the fans follow them hole after hole until they complete all the courses, this can take several days. Certainly, this is a physically demanding experience for attendants as they would need to walk tiring distances every day, but there are other options to experience the event. Attendants can go to designated areas to sit and watch the event on screens along with other fans, they can visit restaurants, explore stores for golf fans and spend their time at the fan zones. The last item mentioned, the “fan zone” was the most interesting finding about these events, these are designated areas with resting places, tables, games and entertainment meant for golf fans and their families. Although most of the activities are linked to golf, a lot of them are just there to entertain kids and adults, having no relation to golf. The activities mentioned included musical performances, mini golf, trivia games, toy cars and carnival rides. This finding proves that there's more to golf tournaments than most people think and it also opens the door to multiple possible activities to be introduced prioritizing entertainment and enjoyment.

4.1.5 Secondary Research

Following the method of secondary research the following step of the research was to look for other sources to complement the information learned from the interviews and to understand some of the concepts that came up in the discussions that were new for the research or required further investigation to understand them.

At this point in the discovery stage it was useful to refer to online resources to fill the gaps in the information from the interviews, this was very useful for understanding what the fans mentioned
about the golf tournaments. There were extensive journalistic records about the fan zones and how the attendees experience the event.

Figure 9. Fan Zone at Travelers Championship (From https://www.youtube.com/watch?v=x1vycDo4bWc)  
Nexstar Broadcasting, Inc. | All Rights Reserved.

In the images (Fig. 9) is possible to see the diversity of activities that a fan zone can contain, proving how the fan zones open the doors to diverse activities and how open the attendees are to participate in activities related to golf and other types of activities, enjoyment is the key.

As useful as the secondary research was to learn more about golf live events, it wasn’t a proper source to fully understand the experience of playing golf. This led the research to the playground itself, to experience golf in the wild.

4.1.6 Getting out of the lab to experience golf

Any physical activity can be studied but it can be better understood by actually taking part of said activity, there’s a limit to what words can communicate and there are others that people can completely overlook, thinking they are not important, while they might be crucial for other individuals. This is the case of playing golf and how playing the game and experience it from the
point of view of interaction design can help to understand the information provided by the fans and to explore information they may have omitted.

Figure 10. Hylliekrokens Golfcenter in Malmö, Sweden (From https://hylliekrokensgolf.se/)

The concept of getting out of the lab and experiencing the subject of research first-hand has been constantly encouraged in interaction design, and the play session at the Hylliekrokens Golfcenter (Fig. 10) helped to properly understand the information gathered from the fans and see the experience through their eyes. Another benefit from this hands-on research was that it facilitated the identification of the game properties of golf, something necessary in order to move to a converging stage of defining the direction of the design project.

4.1.7 Conclusions

Applying the unstructured interview method complemented with IDEO’s method turned out to be very effective, although not all the questions were properly discussed, but the freedom of the open discussion allowed the fans to take the conversation in the direction that better fit their interests. The fans were more engaged because of talking about something they are passionate about which helped them to share personal experiences more openly. Another factor that helped was bringing up the information they shared in the preliminary “design before design” call, which brought forth visceral reactions in the responses, showing clearly what parts of the fan experience they particularly enjoyed. Even if each discussion was different from the next one there were several points in common that led to valuable insights about the experience of
playing golf and attending a golf event. Later on, the secondary research helped piece together all the parts gathered from the interviews, and practicing the sport helps to understand the game concept of challenge, obstacles and mastery in terms of golf.

4.2 DEFINE

4.2.1 The MDA properties of Golf: Mechanics

In the definition stage, the goal is to synthesize all the information gathered to determine what experience to design for and the first step is to take the information and start analyzing the mechanics, dynamics and aesthetic of golf in order to implement them into an AR experience. The mechanics are all the actions and game functions that can happen in a game, and when all the mechanics interact together they form a system, which is defined as the dynamics. The following image (Fig. 11) shows the analysis of the mechanics.

**Figure 11. Game mechanics of golf. By Daniel Velasquez**
The mechanics involve all interactions, including player triggered actions, and the ones that affect the players or may counteract their actions. The illustration (Fig. X) shows the 4 main mechanics identified in a game of golf, these are (1) selecting the club, (2) hitting the ball. Then as a result of hitting the ball it might go to (3) interacting with obstacles and does not go in the hole, causing the game to be prolonged. Or (4) the ball may encounter obstacles but goes in the hole, marking the end of the game level or course.

There is a secondary mechanic that happen as a reaction to the player actions, the increase in the hit counter when the player hits the ball. Although this is just the way of the game of keeping track of how many times the player performs the hit mechanic (2), it is worth mentioning this dependent mechanic because the player with the lower score or hit count wins the game. Another mechanic that should be expanded is (3), but perhaps what needs to be expanded is the concept of obstacles in the game. The obstacles consist of objects that cause collisions, like trees, rocks and others, but there are other types of obstacles. One of the additional obstacles are the weather conditions, as these affects the flight of the ball. Sunny weather will stay in the air longer, while dark, moist or rainy weather will do the opposite. The other obstacle is the biggest one, the terrain. The field itself poses the biggest obstacle to the player, from its notorious traps, hills and valleys, to the subtle inclination of some areas of the terrain.

4.2.2 The MDA properties of Golf: Dynamics

The systemic relation of the mechanics forms the dynamics of the game, and these are of the utmost importance because they also represent the challenges of the experience. More precisely, the way the player actions form a systematic relation with the obstacles develops the challenges, this explains why the difficulty increases with more challenges. Moreover, different types of obstacles require different skills to overcome them, shaping the challenges and affecting the motivation of the player. Not all players will be affected equally by a challenge, it depends on the specific interests and skill level of the golfer. Therefore challenges identified in golf can be categorized in two groups, dexterity and spatial awareness.

Dexterity is the challenge towards the need of competence, building up the skills to solve problems. The main obstacles that compose this challenge is the clob, the ball and the players own body. Golfers need to gain precise control of their muscles and understand the implications of hitting the ball in different ways, therefore mastering the skills necessary to overcome the dexterity challenge.
Spatial awareness is an analytical challenge towards the need of autonomy and motivated by curiosity. Autonomy is affected by letting the player choose which is the most efficient path from the starting line to the goal of getting the ball in the hole, which must be done by accounting for their skills, weather conditions and obstacles. Curiosity is aroused by the uncertainty of the outcome of each hit, motivating the player to discover if the ball will land where they predicted after hitting it, making the game feel like a luck based activity mitigated by dexterity.

4.2.3 The MDA properties of Golf: Aesthetics

The challenges generate a specific aesthetic very representative of golf, by leading players to a slow paced game with strategic thinking, observation and analysis, followed by absolute control of the body to perform precise actions. In other games, there’s no time to think too much, while in this one each player action is carefully planned. Even the physically demanding challenges must be meticulously planned, leading to the two concepts that could sum up the general aesthetic of the game, analytical concentration and precise gameplay.

4.2.4 Mapping AR in the modes of play

The next step in the process involved understanding the range of AR experiences for affording enjoyment in the context of ludic and paideic activities. The goal of this task is to bring augmented tools into the same play area as golf to find how AR as a digital material can embody an experience that houses the game properties that have been explored and dissected in golf, its mechanics, dynamics and aesthetics.

Figure 12. Modes of play Vs Goals explanation. By Daniel Velasquez
The proposed method for mapping AR experiences (Fig. 12) involved a variation of the playfulness vs gamefulness matrix (Walz & Deterding, 2015) by adding Csikszentmihalyi’s (1990) proposal of autotelic and exotelic experiences. Putting these two together will help categorize future design proposals not based in the partial or complete implementation of the modes of play but on the purpose of the experience, if it is for its pure enjoyment (autotelic) or if it is meant to achieve a goal external to the experience (exotelic). To define reference points with existing work, the four canonical examples explored in this project were mapped according to their mode of play and the goal of each experience (Fig. 13).

![Figure 13. Canonical examples in the modes of play vs goals mapping. By Daniel Velasquez](image)

The HUD turned out to be the experience that better embodied the concept of a didactic tool, a playful experience completely intended to fulfill an instrumental goal. Meanwhile, the other three were offered a ludic experience but with different characteristics. Pokemon Go, while being a fully fledged game is inclined to have the exotelic purpose of getting gamers out of their houses, something that successfully achieved. The A(i)R Hockey game proved to be completely autotelic but it had a dual game mode inspiration as player would in some cases only partake on the experience out of curiosity and not play it for its gameful qualities but just exhaust their curiosity and then leave the game. Angry Bird AR in the other hand, while having playful elements, it’s played for its gameful characteristics. This proves how the mindset of the users may determine the experience they have, whether it is ludic or paideic.
4.2.5 Workshop: Collaborative ideation from the “define” stage to the “develop” stage

With the golf game properties identified and having the tools to qualify the experiential vs instrumental goal of an AR experience the next step was to go back to the fans and stakeholders to have a workshop with three activities. The first one was a simple ideating sessions about what moments or spaces they see as design opportunities that can be enhanced with an AR experience, followed by a discussion to hear any reasoning or counterpoints.

![Figure 14. Activity one - Modes of play Vs Goals explanation. By Daniel Velasquez](image)

The initial ideation was very useful and pinpointed where the participants would like to have an AR experience. Continuing with the workshop, the next activity was a collaborative ideation of the experiences they would like to have in the previously mentioned spaces. The second activity
was meant to bridge the define stage with the third stage of the double diamond, the develop stage. The connection was achieved by focusing the ideation on the activities that would be enjoyable for the participants, either as the main outcome of the experience or as part of an instrumental goal.

The method in this collaborative ideation activity involved the researcher teasing ideas of things that could happen in the spaces or moments the participants had identified and encouraging them to share their own ideas. Once an idea was accepted by the participants, there was a discussion about it in order to flesh it out, imagining how it would be like to interact with it. Some ideas were accompanied with basic body storming and hand gestures, while the idea about player data visualization was sketched in the whiteboard (Fig. 15).

At this point the participants had a five minute explanation of the modes of play vs goals mapping method, followed by the third and final activity of the workshop, adding a colored dot on a modes of play vs goals mapping sheet to mark the type of experience would be ideal, and giving a short explanation why (Fig. 16). The result was surprising, as they all agreed on the same thing, they want a gameful autotelic experience. The same argument was paraphrased by all the participants, they attend golf events because it’s fun and that the only reason for them to participate and the only outcome they expect.
4.2.6 Conclusion - Fans want a completely ludic experience

The convergent stage was very fruitful, it helped define and structure all the information and defined the guidelines for what the design should be and what’s the expectation of the fans when it comes to an AR experience that relates to golf, out of which the only non-negotiable expectation is enjoyment.

4.3 DEVELOP

4.3.1 Insights from the ideation workshop

The ideation workshop marked the start of the “develop” stage and the collaborative ideation was the activity that started the journey towards defining the final design. The workshop produced two defining characteristics of the final design, the first one being that the main goal of the AR experience is enjoyment and it has to be a gameful autotelic experience (Fig. 16). The second one is that the game should focus on bringing enjoyment to the moments when the fans are not watching the players in the tournament. The second characteristic is given by the first workshop activity, as six out of seven participants described spaces away from the main game in the tournament where they are resting.

The workshop participants did more than define the characteristics of the final design, they kickstarted the design process in the conjoined ideation with the researcher. In favor of efficiency, each one of the proposed experiences was barely structured enough to be called a
full idea, they were more like experiential teasers. The main reason for this was to avoid wasting time on ideas that were not welcomed by everyone and to avoid the workshop from dragging for too long. The good news for the design process is that the same characteristics defined by the participants serve as a filtering method for the ideas. That is why the next activity is to map the ideas proposed by the workshop participants and move forward with the one that fits the criteria they established.

For a brief explanation of the ideas, they started with (1) an AR food purchasing service, in which you can visualize the dishes before buying them. (2) a player data visualization that allows the users to see stats and videos of every player they point their smartphones at. (3) a golf visualization tool, to admire and explore the golf courses as tiny 3D models. (4) Trivia game that will put the user’s knowledge to a test, asking facts about the players and courses they scan with their phones. (5) A virtual card collection game that awards them player cards each time they scan a player, something along the lines of a gamified “baseball card collections” but with golf. (6) and finally, a simulation of a table top version of golf, challenging players to get the ball to the hole in the least amount of interactions, it would be using AR fields that can be spawned in any surface.

![Diagram](image)

*Figure 17. Analysis of workshop activity. By Daniel Velasquez*

After mapping the solutions (Fig. 17) and a thorough analysis of how , the idea that better fitted the criteria was the AR flick golf. The reason is that out of the 3 proposals that exist in the are of gameful autotelic experiences, it’s the one that shows more promise for embodying the 2 main aesthetics of golf. The other two proposals impose a mental challenge, but they show little
promise for recreating the aesthetics of analytical concentration and precise gameplay. On one hand, the dexterity challenge could be added in some way in the trivia game or the set collection, but it would not be an organic addition, it would not feel natural. On the other hand, creating a portable version of golf power by AR would allow for a natural transition of the aesthetics to digital, and it would also be something everyone can play, even from their homes, not just at the event. Additionally, Pokemon Go proved that AR games can put the players dexterity to a test, the task of throwing the monster catching “Pokeballs” at the little creatures is very satisfying when the players master the throwing gesture.

4.3.1 Envisioning how the game will work

To maintain the development exploration divergent, the next step was to go back to the golf fans for a short workshop activity. Inspired by IDEO’s (2015) human centered design workshop methods and taking notes from Gaver’s (1999) use of postcards as probing resources, the idea was to show an image that would suggest an incomplete story, and let them complete the rest of the story. More precisely, the activity would consist of a simple image showing a smartphone with an AR golf field on the screen and a zoomed image suggesting that a swipe gesture can move a golf ball. The participants were to look at the image with just one simple explanation given by the researcher “This is a mobile augmented reality game, from looking at the image, could you answer the two questions?” (Fig. 18). After they had answered, the fans would be informed that such game does not exist, it was only an image to spark their imagination, but they had just created a game themselves.

![Figure 18. Image for storytelling exercise with golf fans. By Daniel Velasquez](image-url)
The results were fantastic, as the fans created whole mechanics, rules and challenges. All the information gathered was studied and the most relevant parts were used in the next step of the project, defining the game’s MDA properties by transferring the mechanics, dynamics and aesthetics from golf into a digital golf game to be played in physical tabletops.

4.3.2 From physical to digital: transferring the game properties of golf

From the analysis of the game properties of golf and the ideas from the fans, a game design was constructed, this was done by creating a list of four parameters or tenets that the game must have in order to stay true to the physical MDA properties of golf and the expectations of the fans.

![Figure 19. MDA properties of golf. By Daniel Velasquez](image)

The image describes the mechanics, dynamics and aesthetics that will be part of the experience, and thanks to the storytelling activity some of this mechanics started to be defined. Following Fullerton’s method of playcentric design, the goal of this stage is to know the aesthetics that the game strives to have and start with some mechanics that might generate the desired experience. For this, each iteration of the game prototyping should aim for the aesthetic of analytic concentration and precise gameplay. Moreover, each attempt will have an iteration in any form of the 4 base mechanic rules that will act as the tenets of the game:

1. The player must be able to control the movement of the ball, and directly affect where it moves performing an action that will test the players dexterity.
2. The player must have the autonomy to choose and graduate the hit of the ball.
3. There must be obstacles in the game area that build on top of the dexterity challenge and the player will have the freedom to choose the desired path and how to avoid obstacles.
The game is won when the ball goes in the hole, then the efficiency of the player is marked by a mechanic that clearly counts the hits, less hits means a better score.

4.4 DELIVER

4.4.1 Designing the AR golf experience

The final stage of the double diamond imposed the challenge of condensing everything from the previous stages into a prototype that embodies all the game properties. To start this process the first task was to define what the game would consist of, as it’s game properties have been defined by the design process and the general characteristics were defined by the fans.

The game concept initially labeled as “Flick Golf”, consists of a smartphone based AR app that allows users to play virtual golf in any surface, acting as a tabletop golf game in which players explore the field by physically moving with their phones around the surface where it is being projected to reach optimal positions to “flick” the digital ball until it reaches the hole.

Figure 20. Design concept for the Flick Golf prototype. By Daniel Velasquez
But before jumping into developing the digital prototype, the first step is to create a physical prototype that will allow to test all the desired mechanics along with the golf fans as game testers. As stated in the method section of this report, physical prototypes (Fullerton, 2014) add a rapid iterative layer to the process as well as adding participatory qualities to the process. Using this playcentric design approach allowed golf fans to become part of the design process and later on, to analyze the physical gameplay and implement any learning outcomes into its digital counterpart.

4.4.1 Physical prototyping for co-design

Following the playcentric method, the physical prototype stage consisted in creating a physical version of the table top experience that allows for quick changes and gameplay a blue sky exploration for the game testers. The purpose of the physical prototype was to be used for co-design workshops with the golf fans, to allow them to test, analyze and recreate the game without the limitations of a digital prototype, that excludes anyone without programming skills to actively make changes and test them on the go. To clarify, the physical prototype is just a tool to test the gameplay and MDA properties in order to include these in the digital version.

The first step was to define how the game will look like in order to make a physical prototype. This question was answered by considering that if the games strives to be a digital version of golf that can be played in tables and any surface, the best way to test it was as a board game or table top game. This meant using a wooden board as the play area.

![Physical prototype for workshop](image)

*Figure 21. Physical prototype for workshop. By Daniel Velasquez*
The second question that needed to be solved was how the main mechanics function in physical objects in the scale of a tabletop game, this meant understanding (1) the physics of how the ball moves, (2) How to simulate a terrain that affects the movement of the ball. (3) Analyzing how the ball interacts with the terrain. (4) Test different types of obstacles (5) Calibrate the difficulty of getting the ball to the hole.

To answer the questions about the physical behavior, several physical objects were used until the research stumbled upon ideal materials for the test as seen in (Fig. 21).

The physical prototype helped answer all the questions, and allowed for close observation and analysis of everything interacted with each other. The first interesting observation was how the player’s hand interacted with the styrofoam ball, which was challenging to maneuver due to its lightweight. Secondly, adding different types of obstacles to generate collisions, and finally understanding how to create a terrain that allowed for the ball to roll over without colliding, just redirecting the ball because of the inclination of the terrain.

Having created a prototype that contains all the physical qualities that the digital game should embody and follows the mechanic rules of the game, the next stage was to rally the golf fans and have user testing sessions.

4.4.2 Physical prototype workshop: designing the gameplay with users

The user testing followed the procedure described by Fullerton (2014), letting the players experience the game without leading them and documenting the tests by taking notes and photos when the testers allowed it. The highlight from the testing was the moments when the game was broken, in some cases, even literally. The game abruptly stopped when the ball fell from the table and could not be found, the ball pushed one of the obstacles out of the field, and the flag was not allowing the ball to enter the hole (that's why it is present in the first photo but no in the others). All of these events are things that should not happen in the final game and were promptly fixed thanks to having a physical prototype that could be patched with glue and tape instead of a digital one that would require hours of code and several testing sessions.
The response from the participants was great, and they were encouraged to try to use other mechanics to get the ball into the hole. This included using their fingers to hit the ball, pens, and other objects. Additionally, there was a test in which they grabbed the game from the table and tried to get the ball in the whole by leaning the board in different directions. Even though it was challenging and fun they mentioned that it did not feel like golf when completing the task in that manner. This raised the question of “what feels like golf?” and after discussing the matter it turns out that balancing the board to get the ball into the hole removes the slow pace, and strategic play because it would remove the hit counter and scoring from the game.

The workshop was a success, as it allowed the golf fans to test and tweak the design to achieve an optimal gameplay experience that afforded the same type of enjoyment they experience while playing golf, and there were new mechanics that achieved that. The two most important takeaways are first, the flicking gesture, it required them to master this action and it must be recreated for the digital experience. The second takeaway was the playful exploration of the board in order to plan a strategy for each flick, which must be adapted to the AR experience to afford the same sense of discovery. With the results of the physical prototype testing and having other two testing sessions it was time to move to the next phase, the digital prototype.
4.4.2 Digital prototyping
This stage had its own set of challenges as described by Fullerton when highlighting the benefits of a physical prototype. Progress was slow compared to the fast physical iterations but the objectives were clear, to recreate the physical experience that had been tested, following the mechanic rules and testing to evaluate if the experience was achieving the desired experience goals set by the aesthetics. The digital prototyping went through several versions, each one evaluated by testing the game with golf fans.

4.4.2.1 Converting physical actions into screen gestures
Before recreating the digital version of the tabletop AR game, the preliminary step was to identify and transfer the user interactions identified in the digital prototype. The first one is the action of moving the ball with the finger, an action that requires dexterous movement and control over one's strength and ultimately determines the direction in which the ball will move.

The action of flicking the ball is a physical gesture with a physical feedback, the ball moves, making the goal for the app design to have a flicking gesture on the screen that accurately captures the strength, direction and precision of the user’s finger movements. This was solved by using the haptic sensors and measuring the trajectory of the touch input from the moment it
starts until it ends, which resulted in the desired type of precise gameplay, in which every aspect of the touch input is taken into account to challenge players into mastering the gesture.

The second preliminary step was to make sure that the playfulness of exploring the golf field, every inclination, and hill in order to plan one’s game. This was achieved by 3D modeling a test field with different terrains and obstacles, and using the AR camera features to fix the field view to the screen, only allowing users to explore the field by physically moving the phone and panning around the surface where the field was projected. This resulted in engaging the whole body and not just the user’s hands and eyes, creating a new layer of body gestures that are necessary to succeed in the game. (video of playful exploration: https://youtu.be/e8494iYQC1I )

The first version of the AR golf game had a field, interactive ball that responded to flicks, and the hole as the main goal. It also included a basic hit counter on top of the screen and a message that would pop up once the player wins the game had a working counter mechanic. At this point, the digital prototype was functional enough to let the fans test it and break it to find what needed to be tweaked.
The response was good but there were things that need to be optimized to ensure better performance, but the testers enjoyed the concept and were eager to test future versions. The goal of the testing was to evaluate if the four mechanic rules were being followed and to evaluate the enjoyment during gameplay. It was clear that the game would require more versions to reach its goal, but it was headed in the right track.

Further iterations helped improve the responsiveness of the flicks, the physics and some graphic upgrades for the user interface. One requested feature from the testers was adding a restart button, as they were so engaged and got so competitive when testing along other players that they wanted to play the level several times, reaching this point, when all the mechanics where in place, following all the rules and achieving the experience goal of enjoyment, proved that following the analysis of a physical activity like golf can be dissected into game properties and mechanics, dynamics can be recreated using AR to afford the same aesthetics.
At this point of the project, the game went through a final revision of every game property and went on to create the fifth iteration, which improved what was needed and solidified the properties that were satisfying the fans.

5. RESULTS & FINAL DESIGN

The result of the design process was a fully fleshed gameful autotelic experience that was created by analyzing the game properties of golf. In its fifth version the game successfully recreated the four mechanics of golf, replicated the systemic relation between them to embody the same challenges of dexterity and spatial awareness.

By following the process proposed in this thesis work and applying a mixture of interaction design methods with game design the game successfully afforded enjoyment, an achievement accomplished thanks to “trusting the process” (IDEO, 2015).
In the final tests, after later tweaks and including the mechanic of choosing your own club, resulting in engaging golf fans even more and affording the aesthetics of analytic concentration and precise gameplay, and ultimately, simply creating an enjoyable experience for fans, not meant to replace the physical game of golf in their lives but to give them the enjoyment of golf by converting any surface into an enjoyable experience for golfers.

Figure 25. Playtester on the left and Tiger Woods on the right.
(Tiger Woods image from www.sportsradiownml.com/category/dell-sports-golf-news/)
There’s no better way to capture the result than with (Fig. 25), a parallel of the golf world champion Tiger Woods, concentrating and analyzing the terrain for planning his shot, versus one of the game testers almost climbing in his desk just the find the perfect angle for the perfect hit, that is what the project managed to recreate, the enjoyment of playing golf.

5.1 Outcome analysis: Golf vs AR Golf

The design project of AR golf started with the idea of transferring the physical properties that made it enjoyable for fans of the sport, and after finishing the design process there are several learning outcomes for interaction design to be highlighted.

When comparing the user’s gameplay experience of golf and AR golf the main observation to highlight is how each game challenges the dexterity of the players and engages their whole body. In golf the bodily engagement is achieved by using the club to hit the ball which demands a coordination of eyes, arms, hip and legs, additionally, players must rely on their eyes to explore the visible terrain and plan the shot. On the other hand AR golf, while being a digital experience, it also achieved player’s bodily engagement but through a different path. While the act of hitting the ball is the mechanic that engages the whole body in the physical game, in the digital game this is done by using finger and eye coordination to complete a swipe gesture on the touch screen, an act that still requires dexterous play but in a different level. The mechanic that engages the whole body in the AR game is the exploration of the field to plan the strategy and where to shoot the ball.

The mechanic used in the AR experience for exploring the field was moving the smartphone around the surface where the game is being projected to view the digital field through the camera of the device. The explorative mechanic invited players to step back and move around to explore the golf course from every angle, but it also rewarded players who would get close to the course to study all the subtleties of the terrain that would affect the movement of the ball and affect their performance.

The simple act of exploring a terrain through the smartphone became almost like having a window to another reality, and added a level of playfulness that the physical game doesn’t have. Another key difference is that the AR game allows players to explore the whole course to plan their game, while the physical game limits this exploration to the visible terrain from where the players are standing. This difference gives the players the opportunity to engage in a more strategic gameplay experience, where they can plan their whole game in advance instead of just planning their next shot based on what portion of the field they can see.

The AR golf game not only augmented the experience of playing tabletop golf in trivial spaces, it created its own identity by taking inspiration from the physical game and creating its own
interactive features that made it different enough to not compete with golf but to offer fans a way to experience the enjoyment of the sport in different ways, spaces and moments.

5.2 Future steps

The next steps regarding the development of the AR golf project are to explore how the individual gameplay experience can be expanded into a shared experience and to test other ways in which the real world can affect the AR experience.

The self-determination theory explained in the theory section of this report, illustrates how enjoyment can be afforded by satisfying the psychological needs of autonomy, relatedness, and competence. While the prototype of AR golf was only designed to satisfy the need of competence and autonomy, the next step is to develop an AR experience that allows for multiplayer gameplay, enabling two or more users to view the same AR projection and compete for the best score. To accomplish the task of creating a shared experience will need further study of the physical game to design the game mechanics that afford an enjoyable shared experience in the context of golf. The digital material that is being used allows for many possibilities to include other players in the game experience but the decision of how to make the AR golf into a social game cannot be arbitrary but based on the analysis of the shared enjoyment experienced on the physical game. The described approach will ensure that the research stays true to the method proposed of a reality aware augmented reality.

The exploration to find other ways in which the real world can affect the AR experience refers to the codependency of the digital elements with the digital space where the simulation is being projected. The 3D graphics that are projected in the real world affect the way the users pensive the space, and in the same manner, the conditions of the real space should affect the digital elements. In the current prototype the light of the real space affects the lightning of the 3D models, but the idea with the further steps would be to explore other ways in which this symbiotic relationship can be developed. An example of this exploration would be to explore how a connection between the game and weather forecasting services could allow the real weather of the real location where the game is being played to affect the behavior of the game mechanics. During the research the golf fans pointed out that the ball behaves differently depending on the weather conditions, staying longer in the air when it is sunny and dropping more abruptly when the weather is rainy. These weather variations could be studied and tested to improve the game’s receptiveness to the real world’s affects.

6. CONCLUSIONS

The project was about creating augmented reality experiences by studying the real world and transferring some of these real world properties into the AR experience. The goal of this is
showing how AR tools have an amazing capacity for simulations that actually enhance real world experiences and it allows for a different ways to use smart devices. Analyzing the experience of playing golf and transferring the same experience of enjoyment to golf fans was a great way to prove how this can be done by carefully studying the physical qualities of the game, its mechanics, dynamics and aesthetics and with a human-centered approach that had the golf fans at the center of each design stage.

Several workshops, ideation sessions, and prototypes took place, every time validating with the audience of the design and finally by trusting the process and taking part in the playcentric design approach with its iterative nature, allowed to reach the point when the goal was achieved, creating an enjoyable experience for golf fans and creating an augmented reality experience that was reality-aware from its conception to its final stage.

7. ACKNOWLEDGEMENTS

Thanks to all the staff at IBM, Henrick, Bente, Love, Yassine. All the testers, and special thanks to Lennart, Emil, and Juliana for their valuable help in the digital prototype, both with programing and the 3D models. Luna, Simon, Anne-Marie and the class of 2018/2019 Interaction Design at Malmö University, thank you for their support with the project.

8. APPENDIX

8.1 Notes from the interviews with Golf Fans:

Understanding the point of view of the users is vital to reveal all the aspects of the fan experience. Most golf fans are golf are both expectators players as well, being able to provide an insightful point of view as practitioners of the sport. Taking advantage of this role duality, the research participants were approached with a short series of open questions, treated more like directed storytelling that kept the doors open to any piece of valuable information that can guide the research.

The main questions were:

1. Do you remember when you started playing golf? How was it like?
2. What challenges did you find while learning to play golf?
3. What abilities have you developed by playing golf?
4. What golf events have you attended?
5. How is a day like in one of these events?
6. Did you use any digital tools? E.g. Website, Application
7. What’s your favorite memory about the event?

The collective answers brought up other important pieces of the puzzle needed to complete the picture of how it is to experience golf as players and as fans. Here is presented a list of the most relevant insights collected, along with an initial analysis of each one of them. These items are divided into two categories, insights about playing golf and a second group that deals with insights related to attending golf events:

8.1.1 About playing golf

- Challenges using the clubs hitting the ball: Humans are masters of their own body, or at least learn to master it after years of practice in their infancy. But when someone is asked to control a tool they have never used before either one of two things will happen, the user will try to handle it in the same way as other familiar tools or if there are no recognizable similarities that connect it with other known tools, there will be a period of clumsiness and frustration in the usage. This is the discussion that happened when talking about using a golf club for the first time, and because of familiarly shaped like a stick many try to wield it as if they were holding a very expensive broom.
- There is a physical learning curve, using a tool that should feel like an extension of the body. The main take away is the clear need to develop dexterity-based skills and users learning to control their own body.
- The importance of concentration: The users shared a very interesting quote used often in golf, saying “Golf is played with the body but won with the mind”, this is used for different sports but has a deeper meaning in the culture of golf. Concentration is something all players acknowledge and respect, because the distraction that external factors can cause can heavily impact the player’s control over their body and their conscious technique
- Wondering where your ball went: Exploring the interaction with external objects, as the users must use clubs to move an object. It’s hard to control where the ball is going and is another dexterity-based skill that needs development.
- The terrain and spatial awareness: One of the most overlooked elements is the terrain, as big as these courses are some people miss it completely when analyzing the challenges found in this sport. The steepness of the terrain, it’s sometimes not so subtle hills and valleys, sand traps and water bodies are the opponent all golf players face and need to conquer. Fans pay attention to this element and when they act as players are constantly analyzing how to best approach each hole in order to get the best score.
8.1.2 About golf events

- The biggest events in golf are the tournaments, and among them there are some giants that stand taller than the rest. These monumental events are the Masters Tournament, PGA Championship, The U.S. Open and The Open Championships.

- Scandinavian Invitation is the biggest tournament in Scandinavia. It was recently renamed, as it was previously known as the Nordea Masters.

- The location of the Scandinavian invitation has not changed from the previous year, even though golf tournaments change their course every year.

- There are different things the fans value at the events, one of them is data about players. This is regarded as an insightful piece of information to make predictions about the games, knowing the stats of your favorite players is expected. In contrast to this practical information, the other thing they value is any opportunity to interact with anything themed with golf. The options and examples are vast, it can be watching interviews, participating in debates, discussions and what they simply call “fun experiences” involving golf.

- The attendees must walk all day following the players through the course, it’s physically demanding and can take over an hour walking to go from a far point of the course to any fan resting places or to get food and beverages.

- TV coverage never does justice to the verticality of the terrain, the hills and valley sections of the golf course are taxing for the people walking and for the players attempting to conquer the course to reach the green.

- Walking and following the tournament contestants is not the only way to experience the event, some fans decide to stay in designated zones and watch the event on screens, and they do it for part of the event or decide to watch the whole event from these convenient locations, having access to all the commodities you would expect in one of these events.

- Most attendees go with their families, which means that not all of them are equally interested in golf. Families stay in designated spots to watch the game from afar or engage in other activities.

- All golf events have designated spaces that transfer from one event to the next. Some of the commonly found spaces are restaurants and food zones, resting spaces, sponsor tents, merchandising stores and fan zones. The last item on the list is very interesting as it is a zone dedicated for fans to rest, watch the game from a comfortable location and they have different activities that change according to organizers and sponsors. The main objective of these spaces is to entertain the golf fans and their families.

- Golf events are spaces for the fans to engage with golf beyond just watching the professionals play. The attendees have activities during the evenings and nights that allow them to share their love for the sport, some are directly connected to golf, and other ones are just spaces to share experiences along with other fans. Some of the examples discussed were interviews with experts, trivia, and other experiences like musical performances.
• These spaces represent design opportunities for experiences that can be enjoyed in the resting spaces, tables and chairs. Or experiences that engage the less passionate fans with the key elements of golf.
• Attendees must whisper or stay silent while in the course watching the contestants play. This is to avoid distractions that could cause them to miss their shot. There’s a huge culture of respecting the mental game in golf. To this end, the antennas in the field, used for digital communications and IoT are painted in the same color of the trees so they can blend in with the landscape and avoid distracting the players.
• Some events limit or totally forbid the smartphone usage when in the field with the players, as a measure to avoid distractions.

9. REFERENCES


