DESIGN, DEVELOPMENT AND USABILITY OF A LOCATION-BASED GAME

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ABSTRACT

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Location-based games (LBG) have been created with the aim of blending reality with the virtual world. At its core, LBGs utilize user location as the main element since they can be played almost anywhere. The LBGs have been reported to positively affect several aspects of the player’s life, such as increasing exercise, learning about the environment, and socialization. These characteristics have led to the implementation of location-based games in education, tourism, and even health-related fields. Many studies have focused on the social aspect, game design, and creating a game world based on real-world locations. In this thesis, an LBG based on the campus of Middle East Technical University is designed and developed. The aim is to evaluate the usability and the interaction experience of players with the real and virtual points of interest in the environment. Ten students participated in a test to play the game. Furthermore, an interview was conducted after the test to evaluate the usability of the game and player’s experience with interacting with the points of interest. The game logs and in-game statistics were also used to support the interview findings. The results showed that all the players had a positive attitude toward playing the game. Regarding the points of interest, the majority chose the interaction with points related to physical objects as they could learn about the real-world locations by interacting from a virtual world.

Keywords: Location-Based Games, Usability, Human-Computer Interactions, Point of Interest
ÖZ

KONUM TABANLI BİR OYUNUN TASARIMI, GELİŞTİRİLMESİ VE KULLANILABILİRİLİĞİ

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Anahtar Sözcükler: Konum Tabanlı Oyunlar, Kullanılabılırlik, İnsan-Bilgisayar Etkileşimleri, İlgi Çekici Nokta
This thesis is dedicated to the 1500 beautiful souls who left us in "Bloody November" 2019 and shed light upon the path of freedom. They will always be remembered.
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<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>LBG</td>
<td>Location-Based Game</td>
</tr>
<tr>
<td>PoI</td>
<td>Point of Interest</td>
</tr>
<tr>
<td>SDK</td>
<td>Software development kit</td>
</tr>
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<td>API</td>
<td>Application Programming Interface</td>
</tr>
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<td>OSM</td>
<td>OpenStreetMap</td>
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<tr>
<td>PCG</td>
<td>Procedural Content Generation</td>
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<td>APK</td>
<td>Android Package Kit</td>
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<tr>
<td>XML</td>
<td>Extensible Markup Language</td>
</tr>
<tr>
<td>CSV</td>
<td>Comma-Separated Values</td>
</tr>
<tr>
<td>AR</td>
<td>Augmented Reality</td>
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<tr>
<td>UI</td>
<td>User Interface</td>
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<td>FPS</td>
<td>First Person Shooter</td>
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CHAPTER 1

INTRODUCTION

Location-based games (LBG) have been emerged with the commercial use of mobile devices with embedded Global Positioning System (GPS). Due to gaining access to GPS and other location aware technologies through personal mobile phones their focus shifted from academia to commercial games. The release of Pokémon Go in 2016 by Niantic changed the public perception towards location-based games. With incorporating augmented reality technologies, it provided its players a new perspective on gaming by blending mobile games’ virtual world with the real environment, turning the urban places in the cities to the playground.

Although location-based games earned popularity after the release of Pokémon Go, the root of this genre of games can be traced back to the time before smart phones and GPS (de Souza E Silva & Hjorth, 2009). For the last two decades LBGs have been a subject of study in the academia and even though it is a recent field of research, studies have been conducted to implement LBGs in areas such as education and tourism due to mobility and social aspects of these games.

LBGs are defined with different terminology in literature. Due to their pervasive nature scholars define them as a sub-category of pervasive games (Montola, 2011). Since they aim to converge the real and virtual world for the players, the terms such as mixed-reality (Viinikka et al., 2016), hybrid-reality (de Souza E Silva & Delacruz, 2006) are used to define them. Terms such as AR games is also quite popular since some LGBs implement augmented reality (AR) technologies in their design.

The different aspects of LBGs have been studied through the years. Researchers have tried to analyze the effects of LBGs on players’ learning (Avouris & Yiannoutsou, 2012), movement (Colley et al., 2017), cartographical knowledge (Lammes & Wilmott, 2018) and social interactions (Montola, 2011; Spallazzo & Mariani, 2018) throughout the playing experience of the player.

One of the main elements of the LBGs are points on the map that are located in certain location by designers so that players can travel to those point and trigger a game event. These points usually have a value either culturally or historically that contains a meaning that can raise the interest of players (Laato et al., 2019b). These
points are called points of interest (PoI). PoIs have been placed in the game map with different methods by designers including manually setting up these points, using data from players and also using algorithms to randomly scatter these points on the map.

Both commercial and research based LBGs have leveraged these methods to design and populate their map. The commercial games are mostly playable everywhere around the world and use more advanced systems such as having a large database containing all the points on every place. In contrary, for research based and individual projects collecting such amount of data and maintaining it can be quite time consuming and costly.

Having a database is not the only difference between the commercial and research-based projects. The scale and time frame for playing these games are also different. The commercial LBGs can be played without any time or place constraints whereas the smaller projects usually take place in a specific time and place. This characteristic of the commercial LBGs is the main reason that makes them pervasive games.

Considering the definition of play by researchers such as Huizinga (1955) and Tekinbas and Zimmerman (2003) that play is happening inside the boundaries separate from daily life and with a set of rules that forms a magic circle for the player. LBGs are known to push and challenge the boundaries of the magic circle regardless of time, place and social interactions. The reason is that these games can turn any place to a playground and be played anytime without conforming to the boundaries of magic circle that is primarily defined.

1.1. Contributions of Study

Even though the definition and different aspects of the LBGs have been a subject of research in academia, the majority of the research are based on few popular commercial games. The research-based projects are usually taken place in a small area in a limited time and the PoIs are set manually to achieve meaningful points that users can relate.

However, game elements such as PoIs are the main reason that players travel on the map with the purpose of collecting items at those points or interacting with a real object or meet other players to socialize. Therefore, these points are crucial in designing an LBG to provide better game experience for the player. Although many research have been done on the narrative, graphical features such as AR and gameplay, the evaluation of PoIs and the interaction of players with them are understudied in the literature.

This thesis aims to design an LBG based on the design criteria in the literature and generate PoIs for the game area automatically based on the data collected from OpenStreetMap (OSM). The aim is to generate PoIs that are meaningful to the game map of the project and also make use of the points that are not containing any historical value and make them relevant for the players. The players’ experience
while interacting with these PoIs and their perception of converging the virtual real world will be analyzed.

The study in this thesis made the following publications possible:


1.2. Research Questions

**Research Question 1:** What are the usability issues specific to the location-based games?

**Research Question 2:** What are the main factors that make a point of interest appealing to the player?

**Research Question 2a:** What type of points of interest players prefer to interact with?

**Research Question 2b:** Can points of interest alter players’ perception of real world?

1.3. Outline of the Thesis

This thesis is consisted of five chapter. The chapters and their description are listed below:

Chapter 1 - Introduction: this chapter provides information on the background of the study and stating the significance of the study and presenting the research questions.

Chapter 2 - Literature Review: this chapter presents an overview of the studies in the literature regarding LBGs. It discusses the history of evolution and formation of LBGs and presents the previous studies regarding social aspects, PoIs, benefits and risk and lastly the evaluation of the LBGs and usability in game.

Chapter 3 - Methodology: The methodology used for data analysis and data acquisition process are explained. Furthermore, the design and development of the LBG for this thesis is explained in detail.
Chapter 4 – Results: The findings from the analysis of the collected data are presented in this chapter.

Chapter 5 – Discussion: This chapter highlights the discussion of the findings.

Chapter 6 – Conclusion and Future Work: This chapter summarizes the work done in this thesis. In addition, it highlights the limitations of the study and future improvements possibilities.
CHAPTER 2

LITERATURE REVIEW

This chapter provides an overview of the literature on location-based games and is composed of eight parts: location-based games definition, social interaction, Benefits of LBGs, Points of interest, Role of maps in LBG, Risks of playing LBGs, usability and synthesis. Since the research on location-based mobile games started in the beginning years of the millennium, several terms and definitions have been used for these games. Therefore, the first part of this chapter focuses on the evolution of the design and development of location-based games.

2.1. Evolution of Location-Based Games

To understand the concept of location-based games it is necessary to explore the pervasive games, concepts of play, game, and magic circle. John Huizinga (1955), one of the pioneers in game research claims that the act of play occurs separately from ordinary life but engaging players completely. Although players do not achieve any materialistic outcome, it happens inside spatial and temporal boundaries and adheres to rules that are determined (Huizinga, 1955).

Tekinbas and Zimmerman (2003) discuss that in Huizinga’s definition the act of play and games (Huizinga, 1955) cannot be distinguished as, forming a social group can be an effect of play. They propose a new definition based on aforementioned term of play in which claim that a game is a structure with set of rules that players participate in an unreal dispute to achieve a measurable result. Tekinbas and Zimmerman (2003) mentioned three types of play:

- *Game play*: playing according to formal rules of game
- *Ludic activities*: includes non-game activities, such as shooting a ball to the wall repeatedly.
- *Being playful*: It is a broad category and includes the idea of being playful alongside play.

Montola (2011) categorizes LBGs into physical, local, global and glocal. Physical games are often named event games requiring specific hardware, props, and costumes. The Location is not a critical factor in this category
since they use hardware instead of mobiles and cannot be played again at another time. Local games should represent the physical world around the player and are based on geographical information of the environment; an example is a game for tourism. Global games integrate Global Positioning System (GPS) in their gameplay and can be played at any location around the player, such as Ingress or Pokémon Go. Glocal games do not have the restrictions of the local games; however, their content is based on local information and places (Spallazzo & Mariani, 2018).

LBGs such as global LBGs are spatially and temporally pervasive since they combine the physical and virtual world and are based on mobiles. The game board can be any place they are located and can be played anytime (Spallazzo & Mariani, 2018). They can impact the arena of play (Stenros, 2014), namely, an area that is physical, temporal, or conceptual that is identified as a structure for play. However, de Souza E Silva and Hjorth (2009) argue that the game and players do not turn the city into the playground, on the contrary, places can have playful characteristics.

LBGs became popular in the early 2000s with the advent of mobile devices and GPS technology. The early projects in this period are referred to as ‘locative media’ (Leorke, 2019). LBGs became popular after US government made the GPS signal data available for public usage on 1 May 2000 (de Souza e Silva & Sutko, 2011). The first LBGs, Mogi and Botfighters, were released. They were the first mobile games to integrate players’ location in their gameplay. Botfighters was a massive multiplayer online game developed by it’s Alive in 2001. The players had to battle with others by finding their location in the city (Spallazzo & Mariani, 2018).

On the other hand, Mogi utilized GPS-enabled phones to allow players to explore and collect virtual game objects by locating them in physical space. The game was released by Newt in 2003. Both mentioned games changed the perspective towards games by making players play in the real world and interact with virtual objects even though they had a simplistic design in terms of gameplay and graphics.

Several different terms have been used for LBGs. The term mix-reality games are suggested by researchers (Montola, 2011; Viinikkala et al., 2016) since they blur the line between physical and virtual worlds and combine them to create the game experience. Another study refers to them as hybrid-reality games (de Souza E Silva & Delacruz, 2006). These terms have been derived from the virtuality continuum (Milgram & Kishino, 1994), which places real and virtual environments on opposite ends of the continuum (See Figure 1). Augmented reality adds virtual elements to the real world, and Augmented virtuality adds real elements to a virtual world. The paces between the extrema of the continuum are where the mixed-reality happens that blends the physical and virtual worlds thus physical and virtual element can be displayed at once. LBGs are characterized by the production of a dual experience of space in which the users see both the physical area around them and a representation of that space on their mobile devices (de Souza E Silva & Hjorth, 2009).
In other studies, regarding the LBGs, these games have been mentioned as geolocation games (Silva et al., 2017) since they integrate geolocation in their gameplay. However, not all location-based apps fall into the LBG category. Since some apps implement maps, and although they contain playful elements, they are not defined as games. They lack rules and game objectives (Tekinbas & Zimmerman, 2003). Lammes and Wilmott (2018) claims that these apps while being a social networking tool, include gamified elements and use the term ‘quasi-games’ because of this hybridization. Some of the researchers prefer the term location-based network (de Souza e Silva & Sutko, 2011). Arango-López et al. (2017) define LBGs as a game that integrates location technologies, and for the central element of the game, locations of one or more players are added. Carneiro et al. (2019) claim that the main components of this definition are technology and rules since, to form an LBG, both game elements, and location-aware technologies are required.

LBGs have been a subject of research in academia alongside the development of commercial forms of these games by companies. However, the two are distinguishable by a set of factors. Commercial LBGs aim to reach and access a big audience; to achieve that, they provide the opportunity to play them anytime and anywhere for the players. Non-commercial games, on the other hand, restrict the time and the place to play and is more suitable for events (Spallazzo & Mariani, 2018). Markus Montola (2011) describes event games as games are specific to an event or social occasions that range from an hour to a day and individuals participate to play and playing area can either be the entire city or a block in the city.

Player movement to areas not defined for gameplay can expand the magic circle while playing pervasive games (Montola et al., 2009), challenging and often violating the characteristics of the playground such as being confined and well-defined. According to Montola (2011) games such as Pokémon that fall into the global game category can be considered pervasive since there are no place and time restrictions for the player. On the other hand, physical and local games are not pervasive since they are played at a specific time and place and use certain tools and not mobile devices (Spallazzo & Mariani, 2018).

de Souza E Silva and Hjorth (2009) consider the Henri Lefebvre's (1974/1991) idea of social spaces to examine the playful nature of locations. The concept of social space implies that spaces are made rather than simply existing. The conventional

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Figure 1: Virtuality Continuum (Milgram & Kishino, 1994).
view of physical and mental spaces, however, is that they exist outside of social practices. Throughout their history, the relationship between economics and power is reflected in the spaces they occupy. Thus, communal spaces become social products. According to Lefebvre (1974/1991), social practices, representation of space, and representational space are the three components of social spaces. Perceived space emphasizes daily life routines and connections between places of work and residence. Conceived space refers to the place's conception by architects or the designer at the time of building, whereas lived space refers to the locations that artist and poets have lived (de Souza E Silva & Hjorth, 2009).

Considering that the combination of social practices produces the space and as something that has been constructed and used by people, space can be conceived not only as social spaces but also playful spaces, since play is an intrinsic social movement by the relationship between people (de Souza E Silva & Sutko, 2008). Urban places are playful spaces due to the movements and interaction of the inhabitants of these areas (de Souza E Silva & Hjorth, 2009).

The concept of play (Huizinga, 1955) is challenged by the concept of a playful area in that play is described as a separate action from serious life. Huizinga (1955) describes four elements of play as:

- Forming the magic circle that explains boundaries between play and daily life
- Feeling immersed in play space
- The liberty in performing activities
- The presence of certain rules

Play’s role in human culture (Huizinga, 1955) and the statement by Rodriguez (2006) that even the serious activities contain fun elements, are opposed by scholars who consider playing distinct from daily life (Tekinbas & Zimmerman, 2003). Considering this, with a focus on play as ludic, de Souza E Silva and Hjorth (2009) add on the elements of play proposed by Huizinga (1955) to understand the playful space as follows:

- Challenging and blurring the boundaries of ordinary life and play therefore challenging the magic circle.
- Immersion in physical space transformed to form the immersion of play space can also be a means to rediscover urban places.
- Liberty in activities is connected to spontaneity, which is described as movement without a plan based on the space (Rodriguez, 2006).
- Rules can become a guide to exploring space and not as a goal by themselves.
2.2. Point of Interest

Every map, whether physical or virtual, contains locations representing a specific place or point in the physical world or a virtual game object on the real-world location containing something of interest named as point of interest (PoI). PoIs enable players to interact with these points by combining physical locations and virtual objects (Laato et al., 2019b).

In a study three aspects proposed for investigating PoIs: 1) safety and accessibility of PoIs, 2) the impact of PoIs on the amount of immersion, and 3) affordance (Norman, 1999) to the gameplay (Laato et al., 2019b). The PoIs can heighten the immersion if they have a unique name, they are based on physical world objects, and they provide information such as pictures for the PoI in that location (Laato et al., 2019a).

The points of interest in Pokémon go are categorized based on their priority and importance in the game, and physical objects in the real world are ranked based on these priorities. (Laato et al., 2019b). The information regarding the PoIs can positively affect players' enjoyment while interacting with their environment as a place of play and have a feeling of attachment to the place (Oleksy & Wnuk, 2017). In addition, players can form attachment to the virtual world to a degree that they might try to preserve it (Papangelis et al., 2017).

PoIs can be generated in two distinct ways. One method is using algorithms to create procedural (Shaker et al., 2016) and random points. The second method is manually creating points using crowdsourcing and generating PoIs by designers and developers (Tregel et al., 2017).

Procedural content generation (PCG) is defined as methods for implementing algorithms to create PoIs randomly and with the least human effort for a considerable number of resources. PoIs created with PCG depend on the algorithms used (Laato et al., 2019b); however, manually created PoIs can generally achieve more robust results (Shaker et al., 2016).

Tregel et al. (2017) proposes a PCG algorithm that creates PoIs on real-world locations based on the data from OpenStreetMap (OSM). OSM is an open-source project started by Steve Coast in 2004 at University College London. Every internet user can access and retrieve geographical data and implement it in their project. OSM has been created to achieve a complete world map with the possible details through the contribution of volunteers (Zielstra & Zipf, 2010).

The approach is criteria-based and uses the OSM tags group to identify areas and points to generate PoIs. These points can have a higher density in urban places such as universities, museums, and places with cultural backgrounds. However, by utilizing the OSM tags and benefitting from the variety of categories they include, it is possible to define simple places and objects that can be found in urban areas, such as bus stops and sidewalks (Tregel et al., 2017). The OSM includes three different elements. These are nodes, ways, and relations. Including and excluding the value of
these elements makes it possible to generate meaningful PoIs and eliminate the points that can be dangerous or private. This method might eliminate the bias toward creating POIs in rural areas since they have a smaller number of PoIs (Colley et al., 2017) due to the quality of data and content of rural places and neighborhoods of minorities. OSM by itself can be biased (Zielstra & Zipf, 2010). A study on OSM revealed a major gap in the available data on cities' urban and rural areas since larger cities have far more active contributors. Furthermore, a drastic change has been observed between large and medium-sized cities (Zielstra & Zipf, 2010).

Another study by Juhász and Hochmair (2017) adds extra factors regarding areas with low coverage of PoIs. They claim that the presence of universities, parks, and shopping malls affects the amount of PoIs however, on the other hand, natural places such as lakes and forests have low data coverage, and it is hard to find PoIs. This type of socio-economic and geographic bias leads to a loss of interest in playing the game and negatively affects the player experience with LBGs.

Finally, the crowdsourcing method is used because mapping the whole world is a difficult task. Some of the LGBs and location-based social networks (de Souza & Frith, 2010) provide the possibility to submit and review PoIs to be added to the database (Celino et al., 2012). OpenStreetMap also takes advantage of this method to map the real world (Haklay & Weber, 2008).

The criteria that Niantic (2019) suggested for accepting PoI from players:

- Places with historical value
- Unique or valuable architecture
- Local spots that are not well known
- Libraries that are public
- Places of worship

PoIs generated automatically by algorithms or in a pseudo-random manner can cover a larger area and provide more PoIs to play. However, it can be dangerous since it can put the players in danger or trespassing.

Randomly created PoIs also have the advantage of maintaining some novelty in the game. In addition, they encourage players to travel to new and interesting places (Laato et al., 2019a).

PoIs are crucial for the LBGs, a game like Ingress is studied in a research and two major factors including outdoor activity and finding new places were highlighted as the reason for playing (Söbke et al., 2017). According to Tregel et al. (2017) PoIs are the center of gameplay in LBGs that players visit them for interaction.

Even though PoIs have positive impact on the gameplay, they can cause major issues regarding trespassing into private properties or restricted areas (Motsinger, 2017).
This issue can be tackled by developers of the game by excluding PoIs from private properties and restricted areas via OSM tags (Laato et al., 2019b).

Figure 2: Screenshots of Pokémon Go (left) and Jurassic World Alive (right).

The Figure 2 illustrates the same location and time with two different approaches for populating the map. The Pokémon Go map is almost empty whereas the Jurassic World Alive map contains more PoIs. The latter implements algorithms to generate PoIs randomly. Although it populates the map with elements on different spots, some PoIs are placed in the middle of the roads. The mentioned games both lack PoIs that are related to physical objects in the real world. The distribution of PoIs in these games highlight the arguments that randomly generated PoIs are suitable for locations that lack places with high cultural value or importance (Colley et al., 2017; Juhász & Hochmair, 2017).

2.3. Role of Maps in LBGs

With the increase in popularity of location-based games and phones equipped with GPS, Users can use the map on their phones’ screens for navigation and playing. This allows players to get information about their real-world location by a graphical element on the map and across multiple planes as spatial self (Schwartz & Halegoua, 2015), which can provide the opportunity to revisit the spatial relationship of players (Lammes & Wilmott, 2018). spatial self is a theoretical framework that encompasses
the process of online self-presentation through the exhibition of offline physical actions (Schwartz & Halegoua, 2015).

LBGs use two variations of maps. Games such as Pokémon go and ingress use highly graphical maps that exclude information regarding street names, building names, and icons on the regular map for points of interest. Other LBGs implement regular topological digital maps such as (OpenStreetMap and GoogleMaps) which include cartographic information about cities, streets, and points of interest (Lammes & Wilmott, 2018).

By using these maps for playing instead of the sole purpose of navigation, new meanings can be defined to the maps. This allows LBGs to be in harmony with the cartographical board games in the sense that both types share mutability, mobility, and hybridization. In addition, it leads to combining the map with the playground and using maps as game boards change the cultural definition of maps (Lammes & Wilmott, 2018).

2.4. Social Interaction in LBGs

The blurred boundaries of space and time can lead to the participation of non-players in the game. The participation can happen without them being aware, and this social expansion of the magic circle would make these games pervasive (Montola et al., 2011). Urban LBGs that encourage players to show behavior such as a weird gesture or a dance move in front of the crowd that seems out of context will involve non-players and strangers, whether they are aware of their involvement (Spallazzo & Mariani, 2018).

Debenedetti (2003) proposed a model for social interaction that can happen in LBG players. The author discusses the together-alone or accompanied-anonymous framework through a semiotic square structured in four modes of social configurations together, alone, not alone, and not together (See Figure 3).

According to Spallazzo and Mariani (2018), the together square describes players that stay together till the end of the game and start together. They also walk on the same route and have the same decisions regarding the interactions in the game and choosing the path. The term affiliation is used to describe this square. The alone square is opposite to the together since the player starts and ends the game alone, makes all the decisions alone, does not interact with other players or non-players, and stays anonymous. The relation of contradiction between alone and together represents the perseverance shown by both towards the social interaction with others (Spallazzo & Mariani, 2018). The team players keep their communication private in their group, and the solo players keep playing solo. The not-together square forms two different relations with alone and not alone square. This square is suitable for the players of a team that would like to split up and communicate voluntarily using verbal, technological, and physical barriers. The not-alone square is in contradiction with not together, and it illustrates a situation in which the player has started the
game alone but wants to communicate and interact with other players and non-players. Suppose a player with alone status is willing to initiate any communication or has to socialize to advance in the game. In that case, the status can be altered to not alone by the player. This behavior can lead to the social expansion of the magic circle and can identify the game as a pervasive LBG (Spallazzo & Mariani, 2018).

Figure 3: Semiotic square of social interactions of players, Adapted from Debenedetti (2003, as cited in Spallazzo & Mariani, 2018)

The social figure of a stranger is defined as being near and far simultaneously (Simmel 1950). The stranger is close to us because we have common characteristics such as nationality; the stranger is far since those characteristics that make us close are common with a large number of individuals. The stranger is a part of a group, a member that has to confront the group and be outside of it to be a part of the group (Simmel, 1950).

Spallazzo and Mariani (2018) suggest that the familiar stranger (Milgram, 1977) makes sense based on Simmel's definition of a stranger and the fact that a stranger can become someone we know if any conversation is initiated (simmel, 1950). Paulos and Goodman (2004) describe familiar strangers (Milgram, 1977) as people we often see but do not communicate with and claim that familiar strangers should be seen regularly, and no interaction should be made. However, the absence will be noticed if that person does not appear in the usual spot. Playing LBMGs can also facilitate interaction with total strangers and familiar strangers and lead to weak social relationships (Granovetter, 1973), while the bond with friends and family is substantial. Paulos and Goodman (2004) mention an unspoken agreement between the familiar stranger and us; however, this agreement can be violated if we meet abroad, or a life-threatening event occurs.
Montola (2011) proposes that interactions that happen by chance can be categorized into three different types: "actual coincidence" happens naturally without interference of the designers; "calculated coincidence," which can be a part of the gameplay and implemented by designers, "fabricated coincidences" are not coincidental and the possibility of it happening is high since it is designed to happen in the game.

2.5. Benefits of LBGs

The characteristics of LBGs are suitable for serious games (Abt, 1970). Serious games are kinds of games that are not designed solely for the purpose of entertainment (Michael & Chen, 2005). Studies in the literature on LBGs stated that these games could contribute to several aspects of players' lives, such as establishing and increasing social interactions (Sobel et al., 2017; Finco et al., 2018). Children playing outdoors while their parents accompany them improves their social relationships (Sobel et al., 2017).

They enrich the relationship of players with their surrounding environment and create an attachment to the places around the players (Oleksy & Wnuk, 2017). Moreover, encouraging players for physical exercises (Alha et al., 2019). LBGs will also blur the border between formal and informal education. (Laato et al., 2019a)

Location-based games are shown to automatically support cartographical and navigational practice if they contain a navigational interface based on real-world maps (Lammes and Wilmott, 2018). The magnitude of the cartographical training depends on how long the game is being played and the PoIs. If PoIs in the game world are not linked to locations in the real world, people are less likely to travel to locations with significance (Laato et al., 2019a).

LBGs can be used as serious games (Abt 1970) for learning. Avouris and Yiannoutsou (2012) categorize three learning types with LGBs; 1) ludic, for entertainment purpose, 2) pedagogic that are LBGs with learning purposes, 3) hybrid that incorporates enjoyment of games in learning. Avouris and Yiannoutsou (2012) describe those serious games (Ulicsak and Wright 2010) are a result of ludic type of LGBs.

2.6 Risks of Playing LBGs

The LGBs offer many benefits; however, it comes with their drawbacks. While they improve players' physical activity (Althoff et al., 2016) and stimulate their interest in learning about their surroundings (Oleksy & Wnuk, 2017), they expose players to a number of privacy concerns. The Time-stamped data about players' location at a specific time can reveal much about users.

Despite the fact that these privacy concerns appear to have a detrimental impact on game play, research of Pokémon Go found that players' privacy concerns do not
correlate negatively with their intent to continue playing (Alha et al., 2019). There are three likely explanations for this: 1) The users are unaware or do not realize the extent of the personal information they are giving away while playing (Acquisti et al., 2015), 2) Those concerned with their privacy do not begin to play and thus do not respond to such a questionnaire, or 3) The users are aware they are giving up their privacy but do not care (Acquisti et al., 2015).

Rauti and Laato (2020) stated that the LBGs collected data is categorized as follows: Time-stamped location data, contextual data, and circumstantial evidence. A player's location at a specific time can be accessed accurately via time-stamped data. The less accurate data types are contextual and circumstantial evidence that, with the combination of other data, can detect the home and workplace location of the player.

Immersion is a major research field regarding LBGs (Hamari et al., 2016). LBGs pervasive nature creates a hybrid mixed reality world that blurs the line between the physical and digital worlds (Viinikkala et al., 2016). Therefore, the immersion factor depends on the extent to which the game is successful in this hybridization (Laato et al., 2019b). Generating points on the map based on the real places. Including social interactions and considering the occurrence of an event in the real world (Laato et al., 2019a).

Immersion can cause major threats to the safety of players. The research on Pokémon go reported the occurrence of driving accidents with pedestrians (Ayers et al., 2016). Players should be more aware of their surroundings while playing to avoid these problems (Serino et al., 2016). Developers of the game have implemented solutions such as a speed limit so the game will not be playable when a car reaches a certain speed. Lastly, the points of interest have been filtered to exclude the dangerous and restricted areas from the game map and warn players by displaying warning messages (Chong et al., 2018).

Even though LBGs can positively influence players' behavior, the threats that come along with them should not be neglected. Combining the game's virtual world with the real world around the player can expand the magic circle and make the boundaries of both worlds undetectable for the user (Karpashevich et al., 2016). This makes players alter their routine daily movements to spot new points on the map and even change their travel time to collect items at certain places (Karpashevich et al., 2016). This type of behavior can harm the players physically and socially (Serino et al., 2016).

Parents of players of LBGs enjoy the increased exercise and time their children spend outside playing LBGs. However, they are worried about how the game might encourage their children to wander into unsafe territory or forget to pay attention to their surroundings while playing (Sobel et al., 2017).

Companies automatically have access to, for example, the players' location data (Hulsey & Reeves, 2014). The available location data can be used for criminal
purposes, for example, to rob a player while they are away from home playing a LBG or to corner and mug a player in a convenient place (Hulsey & Reeves, 2014; Karpashevin et al., 2016).

2.7. Usability in LBGs

Usability is the extent to which a product can be utilized with effectiveness, efficiency, and satisfaction in a specific context of usage, according to the ISO 9241 definition (ISO, 1998). Since games are highly interactive, Human-Computer Interaction (HCI) approaches should be studied. Games and productivity software are different in the sense that in games user interface should not distract the user (Jørgensen, 2004). Microsoft in 1997 implemented usability evaluation methods for the first time in development of games (Jørgensen, 2004).

Rajanen and Tapani (2018) suggest that usability can have several different meanings based on the perspective of the researchers as it can represent the user interface quality or flow, engagement, and fun in the games. Federoff (2002) stated that game interface, game mechanics and gameplay are the three factors that form usability with an emphasis on the gameplay. However, these three factors can be evaluated as user experience by the game developers.

Laitinen (2006) suggest that although that the user interface is emphasized in defining usability, the game platform, gameplay and the type of the game is also should be considered since they are related to each other. Febretti and Garzotto (2009) mentioned that usability is the user interface is between the game and the player and any failure in providing the player with the interface can result in player abandoning the game.

According to Pagulayan et al. (2002) usability metrics are not solely enough, and player experience should be measured. Therefore, he suggests that factors such as ease of use, challenge and pace should be measured to complement the traditional usability evaluation metrics. Ease of use includes components such as simple game mechanics, instructions, user interface in the game and controls that are easy to be grasped by the player.

However, some scholars relate usability to playability. They claim that playability is consisted of game mechanics, game story and gameplay and add the usability to this list as an element of playability (Desurvire et al., 2004.).

The difference between usability and playability is that usability corresponds to the areas of effectiveness, efficiency, and satisfaction. Playability focuses on a broader sense of overall functionality associated with integrating numerous usable tools, enabling successful and pleasurable involvement with a game (Olsen et al., 2011).

However, for location-based games measuring usability can differ due to the nature of the game. Usability of an LBG is how a player can play the game in the game
space that is designed while being able to be safe, control and learn (Gielkens & Wetzel, 2012).

2.8. Synthesis

The LBGs have been studied from different aspects including the three main elements of LBGs that are social, spatial and temporal expansion. These elements form the concept of a pervasive games that LBGs are a part of. The mentioned studies in the literature often used the term mixed-reality for LBGs since the main aim of these games are to blend the virtual and physical world for the player through playing these games.

LBGs main game mechanic is the player’s location based on GPS or other location aware systems while utilizing a digital map as the main game interface. One element that is crucial in design of LBGs is the PoIs since they contribute to the gameplay and overall player movement and decision. PoIs are important in creating a game world that blends the reality and virtual world therefore designers aim to leverage technologies such as AR at the place of PoIs to create the so-called mixed reality.

Choosing spots to place PoIs and a method to place them on the map are also a critical aspect of the design of an LBG. However, studies regarding players perception towards PoIs and the mixed reality in LBGs are understudied and majority of the research are focused on few successful commercial LBGs such as Pokémon go. These aspects can be further studied with implementing the data of games other than the aforementioned commercial games and designing PoIs based on the requirement of a personalized game.
CHAPTER 3

METHODOLOGY

This chapter provides a detailed explanation of the study including the design and development of the game and also the research methodology chosen for this study. Additionally, it explains the data collection and analysis process.

3.1. Research Design

This study aims to design and develop an LBG in order to evaluate its usability. Qualitative data analysis method (Creswell & Creswell, 2018) is selected to provide an in-depth understanding of the data and also help uncover new aspects. In addition, data from the player logs and demographic data of the participants is used to support the findings from the interviews.

The data collection process conducted by an interview after each test and also saving the player logs such as scores, frequency of play and timestamped locations during the test. The test was conducted by playing the developed LBG freely in the campus without any time constraints.

Figure 4: Research methodology
3.2. Developing the MetuGo

The development of the game completed in three iterations including one major change in the fundamental design of the game at the first stage. The Figure 5 illustrates the stages of the development and major elements of each version of the MetuGO.

![Diagram of development stages](image)

**Figure 5: Development stages.**

### 3.2.1 First Prototype

The first prototype aimed to develop a 3D blueprint of the Middle East Technical University (METU) campus (See Figure 6). The model was developed based on the geographical data obtained from the OpenStreetMap (OSM) and the data used to generate the campus model automatically. Coordinates of the campus map were obtained in XML format to develop the game. For presenting the data in the northwest coordinate system on a flat surface, a Mercator projection was applied to the project to transform latitude to X value and longitude to Y value in the left-handed system of the Unity engine. By using the location service of the player on the map, the player could travel the map based on real-world locations. However, the project was discarded by the opinion of an expert due to the lack of cartographical data regarding the buildings and some areas on the campus.

### 3.2.2 Second Prototype

The second prototype of the game, however, utilized the OSM generic map as the navigational interface of the game. Additionally, the points of interest (PoI) generation were implemented manually by adding the critical areas' coordinates to a CSV file and parsing the data to place objects at the selected PoIs. This method affected the quality of PoIs since the density of the points was not even, and some areas had no points for interaction. Furthermore, this method required much work to find and add the PoIs on the map manually.
The player's direction was also missing as a compass was not implemented in the game and could cause confusion for the player while moving on a particular path. The statistics of the game and data of the player were stored locally in the device, which could raise security issues regarding personal data and data manipulation by the players or a third party (Smed & Hakonen, 2017). The data could be lost by uninstalling the game or, in the case of an application crash, that could result in losing the data and player progress in the game. With an expert's feedback, significant changes had to be made in this prototype to achieve the final version of the game.

Figure 6: Screenshot from the unity editor for the first map prototype

3.2.3 Final Version

MetuGo is an LBG that utilizes a digital map that represents the real world around the player as a navigational interface and implements the user's real-time location as the central game element.

MetuGo has been developed using the Unity game engine (Unity, n.d.). The C# programming language is used for developing the game, for it is the only supported language in Unity. C# is an object-oriented programming language that is used for developing an application that runs on .NET.

The cross-platform feature of the Unity engine facilitates building game apps for various platforms, such as mobile platforms. This game is published for Android devices, and the Unity (2020.3.16f1 LTS) version is used to support the latest Android operating system’s versions. Successful commercial games such as Pokémon Go, and Ingress are also developed using the Unity engine.
The MetuGo is designed to turn the campus of METU into a playground. The game world consists of the campus's physical space and a virtual world that is represented by utilizing a digital map as the game's navigational interface.

OpenStreetMap (OSM) is used to illustrate the map of the campus. OSM is an open-source project that uses a crowdsourcing method to map the geographical locations in the world and update the data by contributors worldwide. The geographical locations on OSM are represented by their coordinates.

The GPS and compass of the player's mobile device are leveraged to locate the player on the map and accurately track the location and direction of movement. However, the OSM and GPS location data are in northwest coordinates format. To solve this problem, Mercator projection is implemented on the map to translate these values into X and Y coordinates in the Unity left-hand system. Therefore, the player's location and other game objects on the map based on real-world locations transformed to Unity coordinates.

OSM data model consists of three elements that can represent the geographical places on the map. These elements are nodes, ways, and relations (See Figure 8). Nodes are like points on the map that have a unique id and latitude, longitude values. Ways display roads and areas such as buildings since they are formed by several nodes. Lastly, the relations are used for a specific type of areas such as a lake surrounded by the forest.
Each element contains key and value pair tags that specify their features. Tags are helpful for identifying and filtering the points on the map.

An OSM tile server is used to display the map to the user. A commercial asset (Asset Store, n.d.) is used in this game to access the tile server and load the map in real-time with tiles of the map provided by the tile server. Each tile is a bitmap graphic of the part of a map in a grid cell.

OSM data are in XML format that includes nodes, ways, and relations of an area, providing coordinates and details about the characteristics of any place in the given area. By writing a script to parse the XML file in Unity, we filtered data to eliminate points on areas that threaten players’ safety and set PoIs. The PoIs on MetuGo are defined and ordered based on their importance and generated based on their criteria from their data. However, the data of some points on the campus are unavailable in OSM due to their less cartographical relevance. However, they can be important for people who live and commute on the campus, such as the places where animals are being fed daily, which are only a few specified points on the campus. These points were added by adding the coordinates and tags to a custom CSV file; by parsing the file, we were able to place them in their physical location on the map.

In the final version, an authentication system was applied for the players to register and create an account to access the game. Firebase (Google, n.d.) software development kit (SDK) was implemented for this purpose. The Firebase real-time database was also implemented to save the player's in-game information and logs, such as visited PoIs' locations information. The player progress was saved automatically during the game directly in the database without saving it in local
storage. This led to protecting the data against any crash while running the app, and also it helped to load the objects on the map from the data on the database.

The MetuGo is developed to evaluate the usability of the LBGs and also the players attitude towards the PoIs to analyze the effects on the gameplay. The game's central game mechanic is the player's location in the physical world and tracking the player's movement. The PoIs are created and distributed based on their importance on the campus and their locations. The least important points are scattered on the sidewalks and cycleways for players to collect while walking on the campus. The other elements represent PoIs in the faculties, dormitories, and cafeterias. The most important PoIs were chosen as the monuments and objects with historical value. These points were chosen based on the data from OSM, and points such as roads and jungle that could threaten safety were removed.

The game includes loot boxes as chests that players have to unlock them to acquire items to interact with the PoIs, such as monuments (See Figure 11) and animals (See Figure 13). These items are saved in the players' inventory (See Figure 12) and can be gathered and stacked to use whenever the player desires. By gaining every twenty points, a key is added to the inventory and should be used to unlock the chests to add items such as magnifiers or pet food to the inventory. These items, however, are
inactive upon collection and can be used near the specific PoIs that can be interacted by those items. The game provides hints while approaching the PoIs and, in different cases, guides the player to take a specific action or collect a particular item that is required for the interaction with PoI. The user can access the instruction and statistics about important PoIs in the game while playing. The game items are designed, so the player has to walk and explore to collect them for their purpose.

![Figure 10: Screenshot of the monument information in the game.](image)

As shown in Figure 10 and Figure 11, the player can get information by interacting with the monuments. The information is presented to the player in the form of text and the monument score, and location will be saved in the database. The monuments are shown as purple diamonds while the less important PoIs such as sidewalks are shown in blue. The players can collect the blue items while moving between main PoIs to acquire items and points to unlock chests.

The buildings are presented as red diamonds in the game (See Figure 12) and the chests are distributed on the map for the player to collect required items by unlocking them. The animated animals represent the real-world spots that they are being fed daily and players can interact with them via the food item in the inventory.
The score point and the number of PoIs that are interacted with are presented in the main UI of the game screen. The points are represented by different colors and contain different score points based on their importance.

Figure 11: Screenshot of the PoIs near monuments.

The link for downloading the game is provided in Appendix A. A link for a short video displaying the interactions with PoIs and game mechanics is added in Appendix B.
Figure 12: Screenshot of the game, Lootboxes and inventory items.

Figure 13: Screenshot of the game with animated dogs, points that animal are fed.
3.2.4 Design Constraints

There were a number of constraints regarding the development and also testing the game. The places on the map should have been selected so that they were safe. The location and direction of the player should have been accurate alongside the location of the PoIs. Since the main requirement for playing the game was walking and due to the scale of METU campus testing the game was time consuming. In addition, the differences in the performance of the sensors such as gyroscope and compass were causing problems while testing in different mobile operating systems and different android devices. The problem that was causing delay in the development was that students was not willing to test the APK file of the projects due to the security issues and requested a Google play store link. Furthermore, the first prototypes were not fit to be published on the play store and therefore it was not possible to test the game by many students. With having enough iterations and the publishing phase an immense delay was caused.

3.3 Participants

In this study a single test conducted for players to play the game without any time constraints or presence of an observant. A post-test interview session was held individually with each player.

The sample size for this study was 10 and the age range of the participants were 21 to 30. 3 of the participants were female while 7 were males. The education level of 6 participants were B.Sc. or equivalent and 2 participants had Ph.D. or equivalent. Lastly, 2 participants had M.Sc. or equivalent.

3.4 Data Collection

Ethical approval from METU Human Subjects Ethics Committee was obtained before conducting this study (See Appendix D). The participants were informed about the study’s data collection method during and after the test and signed an informed consent form for voluntary participation in the study (See Appendix E). After the test, players were given a debriefing form to contact in case they were interested in the research results (See Appendix F).

The snowball sampling method (Taherdoost, 2016) is used to access participants. The information about the study was shared on online communities and associations in METU, and the link for downloading the game was provided.

Since the Game takes place in the campus and it includes places that animals are fed, as encouragement contributions were made on behalf of the participants to METU “Pati Dostlari” association.
CHAPTER 4

RESULTS

This chapter presents the results of qualitative analysis of the interview data and also the demographic data collected during the interviews. Game logs and location data of the users are also analyzed to support the findings from the qualitative analysis.

4.1. Analysis of Demographic Data and Game Logs

The data regarding the game preference, time spent on playing games and preferred platform for gaming is illustrated in the table below.

<table>
<thead>
<tr>
<th>No</th>
<th>Age</th>
<th>Gender</th>
<th>Game Preference</th>
<th>Gaming Duration</th>
<th>Preferred Platform</th>
<th>Prior LBG experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>29</td>
<td>Female</td>
<td>None</td>
<td>None</td>
<td>PC/Mobile</td>
<td>No</td>
</tr>
<tr>
<td>P2</td>
<td>30</td>
<td>Male</td>
<td>MMORPG</td>
<td>3 Hours</td>
<td>Mobile</td>
<td>No</td>
</tr>
<tr>
<td>P3</td>
<td>30</td>
<td>Female</td>
<td>Hyper casual</td>
<td>7 Hours</td>
<td>Mobile</td>
<td>Yes</td>
</tr>
<tr>
<td>P4</td>
<td>21</td>
<td>Female</td>
<td>None</td>
<td>None</td>
<td>PC</td>
<td>No</td>
</tr>
<tr>
<td>P5</td>
<td>27</td>
<td>Male</td>
<td>FPS</td>
<td>14 Hours</td>
<td>PC</td>
<td>Yes</td>
</tr>
<tr>
<td>P6</td>
<td>26</td>
<td>Male</td>
<td>Sport</td>
<td>2 Hours</td>
<td>Console</td>
<td>No</td>
</tr>
<tr>
<td>P7</td>
<td>30</td>
<td>Male</td>
<td>Action-Strategy</td>
<td>14 Hours</td>
<td>PC</td>
<td>No</td>
</tr>
<tr>
<td>P8</td>
<td>29</td>
<td>Male</td>
<td>FPS</td>
<td>1 Hour</td>
<td>PC/Mobile</td>
<td>No</td>
</tr>
<tr>
<td>P9</td>
<td>21</td>
<td>Male</td>
<td>FPS</td>
<td>14 Hours</td>
<td>PC</td>
<td>No</td>
</tr>
<tr>
<td>P10</td>
<td>27</td>
<td>Male</td>
<td>None</td>
<td>None</td>
<td>Console</td>
<td>No</td>
</tr>
</tbody>
</table>
The sample size of this study is 10 and the most preferred game genre is FPS games (3) however, three participants do not have any specific game preference. The other preferred games are Hyper casual, MMORPG, sports, and action-strategy games.

The most preferred platform for gaming by participant is PC (6), of which 2 also prefer mobiles as gaming platform. The mobile is the most preferred platform following the PC. Two participants chose console as their main platform for playing games.

The weekly time spared for playing games is shown in Table 1. Three participants claimed that they do not play games. However, three participants stated that they spend more than 10 hours weekly on gaming followed by 3 other participants that play games for less than 5 hours a week. One participant on the other hand spent between 5 to 10 hours weekly on gaming.

Among the participants that played the MetuGo, only 2 participants had experience playing a location-based game. The remaining 8 participant played a location-based game for the first time while playing MetuGo.

Table 2: Interaction of players with PoIs and game controls.

<table>
<thead>
<tr>
<th>No</th>
<th>Monuments</th>
<th>Chests</th>
<th>Inventory Items</th>
<th>Animated animals</th>
<th>Collecting items in the chests</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>P2</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>×</td>
<td>✔</td>
</tr>
<tr>
<td>P3</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>P4</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>×</td>
<td>✔</td>
</tr>
<tr>
<td>P5</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>P6</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>P7</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>×</td>
<td>✔</td>
</tr>
<tr>
<td>P8</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>P9</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>P10</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
The heatmap of the campus (See Figure 14) illustrates the points that players had interaction with virtual and physical related PoIs. As shown in the map most of the interactions of the players have taken place in the area that contains PoIs representing the monuments and buildings. However, the other areas represent the low priority PoIs that have been visited to be able to interact with monuments and also the places that they have started the game.

The density of the points that are most visited and interacted are visible in Figure 15, and it also supports the findings in the heatmap. The central areas of the campus that include historical elements have had the most interaction by players. It is also shown in Table 2, that all the players had interactions with the monuments however the Animated animals that are placed in real points but do not have physical representation have not been approached by all the participants.
4.2. Evaluation of the Interviews

The evaluation of the game was carried out after participants played the game. An interview was conducted to get participants’ feedback on the usability of the game and their interaction with virtual and physical objects. Nine themes emerged from the interview of the players. The themes are listed below:

- Main UI and authentication
- Location accuracy
- Game interactions and Gameplay
- Points of interest
- Virtual and physical interactions
- Awareness of surroundings
- Playing motives
- Play frequency and preference
- Suggestions for improvement

Each theme is explained in detail below:
**Main UI and Authentication:** all participants claimed the User Interface (UI) was simple and easy to understand and they had no issues with registering, logging in or resetting their password. According to the logs of the game all the participants have valid account and their progress in the game is saved. One of the participants noted:

```
The UI was so simple and easy to use, I was able to create my account and login to start the game quickly. (P5)
```

In addition, three participants stated that despite being able to register and login, they had some issues with the UI. These participants stated that:

```
I was not able to use the autofill on my phone to choose my email and I had to type it in the email field. (P3)
```

```
The “forgot password?” is like a text and different from other buttons and I pressed by accident without noticing and had to go to login page again. (P1)
```

```
After the registration, it transitioned to login page fast I didn’t see confirmation message. (P5)
```

**Location accuracy:** Participants were asked to answer questions regarding the accuracy of the objects on the map and player’s location. Seven participants reported the issue regarding the delayed location update in the GPS. They stated that even though they had no issue regarding the accuracy while interacting with points of interests (PoI) and the location of the player, the late update of location while walking was not pleasant. One of the participants noted that:

```
The game character location on the map was updating every few seconds and not the with the pace I was walking, and it annoyed me. (P4)
```

Three of the participants however reported inaccuracy of locations on the map. They stated that some points on the map are not in the exact place as their physical locations. One of the participants noted that:

```
There was inaccuracy like ten meters between some object and their physical place on the map and I had to walk more to interact with it. (P1)
```

**Game interactions and game play:** Questions regarding the game mechanics and in game interactions were asked from the participants. Nine participants stated that after playing for a short time, they were able to get a grasp of the game mechanics and logic of the game. They stated that the UI was helpful to inform them about their status in the game and the hints provided information about the necessary actions in each scenario. Two of the participants noted:

```
By playing I learned that there is a logic behind every item and each one had different function, it was enjoyable. (P6)
```
The logic between items were clear and the UI feedback helped me to understand the game. (P4)

One participant however claimed that they forgot the functions and had to look at in-game instruction to remember the game mechanics. They noted:

I forgot the functions few times and I had to look at the game instructions to remember. Other than that, the hints UI was helpful while interacting with an object. (P3)

In addition, regarding the interactions in the game, nine participants claimed that they did not experience any difficulty while interacting with objects near to them and were able to use game controls and mechanics to interact. One of the participants stated that:

When I was going near points, I could interact with the objects on that location like using my key in inventory to open a chest and collect the item. (P5)

one of the participants however mentioned and issue regarding collecting an item while being near the object. This problem is caused by the radius of interaction in LBGs that can vary based on the placement of the object. They noted that:

When I was near an object sometimes, I had to zoom in to collect an item from a closer distance. (P3)

According to the logs of the game and saved location data, all the players have been able to interact with the objects at their real-world locations on the map and also use game controls since all the elements are related to each other and all should function to continue playing the game.

**Points of interest:** The points of interests are one of the major elements of the LBGs, therefore participants were asked about the PoIs of their preference and reasons for choosing those PoIs. All the participants mentioned that points of interests on the map drew their attention and affected their decisions in game and choosing path. Five participants stated that the points where animals in the campus are being fed was interesting for them at the first sight and they wanted to travel to those points and interact with them since there is also a possibility that real animals would be there at that time. One of the participants stated that:

First thing that got my attention was the animals on the map and I wanted to travel there and interact with them and maybe see real animals at those points (P1)

Two participants mentioned that chests on the map were interesting for them as they looked mysterious and the fact that they reward items to use in the game. Two of the participants noted:
While collecting items on my way near physics department I saw a chest and I wanted to open it and see what is in it. (P6)

Chest drew my attention because of the rewards and items it gives me to use in the game. (P3)

Six participants mentioned that PoIs near monuments seemed interesting on the map, and they wanted to travel to those points and interact with them. They claimed that they were curious about learning about the monuments. One of the participants stated that:

Monuments were interesting for me because I could learn about their history. (P7)

However, all participants mentioned that they found the PoIs at the location of monuments informative, and it helped them to learn about the campus and history of those monuments. One of the participants mentioned that:

The monuments were informative, and I could get information about their history. (P2)

Two of the participants mentioned that they had the chance rediscover the campus and remember the monuments that might have been in places that are out of sights or discover monuments that they have not seen. They noted that:

A monument near the “baraka” which is named “hayalet bisikleti” is not well known and after seeing it on the map it made me remember the story behind it. (P1)

I was always curious about the monuments and read about them on internet but while playing I noticed monuments that I haven’t seen before and was curious to go learn about them. (P3)

The interaction logs of the players in Table 2 illustrates that all the participants have visited the monuments as mentioned in the interview findings however, seven participants have chosen the animals to interact with.

Virtual and Physical interactions: Participants were asked about their perception of interacting with real world through virtual objects. Three participants (P2, P8, and P10) claimed that interacting with virtual items that are placed in real world locations was interesting since they could connect to real world through virtual world. The mentioned participants have no prior experience with LBGs and they spend less than 5 hours weekly on playing video games. One of the participants noted that:

It was an interesting feeling that I could open chest and collect item in the virtual world in a physical world location. (P2)
Five participants mentioned that learning about physical world while observing the physical objects and interacting with them through virtual interface was informative. This shows that these participants perceive the game world as an interface only. One of the participants noted that:

> It felt like museums that you have personal experience through headphones about history while I was in front of a monument and looking at the game screen to read the information at the same time. (P8)

One participant mentioned that they did not feel anything regarding interactions with real world through the game interface.

One participant added that it is similar to treasure hunt and discovery since they have to collect virtual objects in real world that are visible in virtual world. They noted that:

> it felt like I’m in a treasure hunt and have to discover different items and unlock them. (P4)

**Awareness of Surrounding:** The participants answered question related to their distraction while moving between points and their awareness of their surroundings while they are playing and moving. Eight participants claimed that they were not distracted during playing the game and walking between points however they mentioned that they were aware of surroundings. They noted:

> I was focused on game and not distracted; however, I was aware of surroundings, but I wouldn’t notice a friend that passes by me. (P2)

> I wasn’t distracted I was looking at the map to find more items to collect while moving to the next point because I needed items for my inventory, but collectibles were scattered in a way that I had to find them to interact with the next point. (P3)

Two participants stated that sometimes they were distracted while moving between points because of the surroundings.

Participant were also asked about their focus on real world objects while interacting by virtual items that represents that specific physical object. Nine participants mentioned that they were paying attention to the physical objects while interacting with them and moving towards them. One participant stated that:

> I paid attention to Kemal Kurdas monument and there were three monuments near physics faculty so while interacting with one of them I had to check if I’m reading the information of the correct one. (P3)
however, one participant mentioned that they did not pay attention to every monument in that PoI as they are so well known, and they have information about them. They noted that:

*I didn’t look at the monument of Kemal kurdas while reading the information in the game because I see it all the time but the other monuments, I was paying attention to.* (P1)

Two participants mentioned that they were choosing the monuments on the physical world and approaching them to get information on the virtual world. One of the participants noted that:

*While walking in my daily usual way I was choosing a monument that I’m curious about and traveling to use my magnifier to get information about it.* (P6)

The participant number 6 (P6) claimed that he was distracted and also stated that was choosing objects based on the real-world physical object. Therefore, they have used the virtual game world as an interface to acquire information.

**Playing motives:** Regarding the reasons that players continued to play, majority of the participants had one main motive. Nine participants mentioned that the main reason they kept on playing was the curiosity towards the PoIs and elements such as chest and also exploring the campus. One of the participants noted:

*Since the game is based on METU, I wanted to explore the campus while playing the game.* (P7)

Another participant mentioned that finding and feeding the animals was a good motivation since it gave information about the locations that animals are being fed daily in the campus. They noted:

*I didn’t know about these places, when I played, I learned about them and knowing that contributions will be made to pati dostlari, was a good reason for me.* (P3)

One participant however, claimed that the main reason to keep playing the game was the logic of the game and collecting items. They mentioned that:

*The logic and relations between items were the reason for me to keep collecting gems and get keys.* (P6)

**Play frequency and preference:** The participants were asked about their preference on playing an LBG and whether they would like to play the game again. Eight participants mentioned that they played the game only once, however two participants played the game twice.
All the participants claimed that they would be willing to play the game again. A participant stated that:

*If I would come to campus again, I would like to play while walking between places. (P3)*

*I would like to play again and explore more places and also get information about places that I usually pass by them. (P8)*

Participants preference for playing however was different. They were asked if they would like to play in the whole campus map or play at areas that cover their daily routes. Six participants mentioned that they would like to play the game in the whole campus to explore more places. A participant noted:

*I live in the campus, so I prefer to play in the whole campus and explore more places. (P6)*

Four participants claimed that they prefer to play on their daily route and the places they usually visit. A participant stated that:

*If I was new to the campus, I would have wanted to play everywhere but now I prefer to play on places that I usually walk. (P4).*

**Suggestions for Improvement:** The participants provided feedback on the game that they played for the test and also offered suggestions for improvements. Four participants suggested that location accuracy and location update delay can be solved. One participant noted that:

*If the game would use Google maps instead of OpenStreetMap, I think locations on the map will be more up to date and accurate. (P6)*

Two participants mentioned that having a competition in the game and keeping track of other players’ scores could make the game more enjoyable. They stated that:

*A leaderboard can be added so we can see we are competing against other players. (P6)*

One participant mentioned that in-game social interaction can be added to socialize with other players.

Three other participants mentioned that information about other physical buildings can be added to the game. One participant noted:

*Metu has many historical buildings and places such as faculties have many stories to tell. (P2)*
According to the demographic data of the participants and their game play duration, two of the players that play more than 10 hours a week suggested that the game lacks competition elements.

Another finding from the interview that is related to the demographic data is that the (P6) that plays action strategy reported that the game motivation was the logic of the game and the connection between the items.

Table 3: Themes and corresponding quotes.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Results</th>
<th>Quote</th>
</tr>
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CHAPTER 5

DISCUSSION

In this chapter, the findings from the interviews will be discussed in order to answer the research questions of this study. This study aimed to evaluate the usability of the designed location-based game (LBG) and evaluate the interaction with points of interest (PoI) and their distribution on the game's map. The conclusion section of this chapter contains the limitations regarding this study and future work on this study.

5.1. Usability of the MetuGo

According to the findings from participants' feedback on the game, we can conclude that different aspects of the usability in our design favor the players' experience and playability throughout the game. However, some issues can make players experience less enjoyable.

Almost all the participants stated that the user interface (UI) was simple and easy to learn. In addition, for some participants, UI helped access the instruction when they forgot about the game's rules. The UI of the game was reported to be easy to use and informative while interactions in the game happened.

Considering the definition of Pagulayan et al. (2002) for usability, we can conclude that the game mechanics were simple and easy to learn by players. All participants reported that they learned the mechanics of the game easily and understood the logic, and it was easy for them to learn and use the controls while finding the connection between them.

Since MetuGo is an LBG, the mechanics of the game can differ due to the nature of the LBGs, which implement players' real-time location as their main game mechanics. According to Gielkens and Wetzel (2012), the usability in LBGs should provide safe gameplay and easy to learn environment for the players. To achieve this, all the items and PoIs on the map were placed in the areas that are safe to play and PoIs in dangerous areas were exclude based on their OSM tag information.
However, one major issue was reported by three participants regarding the inaccuracies of the map that resulted in the difference between the location of the virtual object on the map and the physical objects. Other players did not experience any issues with inaccuracy; however, they reported that updating location every few seconds while walking and not being able to keep up with the pace of the player was the issue. This issue is mentioned in a study by Xanthopoulos and Xinogalos (2016), and it can be caused because of the embedded GPS technology in the mobile phones and the provider tradeoff since this game implements google location API to access an accurate location by using ACCES_FINE_LOCATION that uses the cellular based location tracking.

All the participants reported that the in-game interaction was clear, and the guidance by UI helped to understand the actions that should be taken. They mentioned that control of the game was easy to use and working well, and they had no problem interacting with PoIs and other game elements.

One of the participants had issues with the interaction with some PoIs, and according to Laato et al. (2021), that claims radius of interaction should not be too small as it can require close distance interaction and some objects cannot be accessible or be interacted with because of location inaccuracy, the radius of interaction is the cause since some objects can be close to each other and traveling to be near these points can be challenging at times. However, in this study the characteristics of the map such as having multiple monuments near each other require more precision and larger radius of interaction can affect the experience of the player.

Febretti and Garzotto (2009) emphasize the importance of UI and the fact that it can make the players not want to play again. In this study, however, all the participants stated that they would like to play the game again. They stated their motives for playing the game were a curiosity to explore and learn about the environment in the campus (Alha et al., 2019).

According to the game statistics and logs of the players (See Table 2), it can be concluded that all the players were able to collect items, unlock chests and add the items to their inventory. They were also able to use them to interact with different PoIs and other game items.

Regarding the first research question, the findings highlight a few usability issues related to the LBGs. The accessibility of the PoIs and interaction with them at certain areas is one of the issues in the design of an LBG. Another issue is related to the inaccuracies of the map that can affect the placement of the PoIs as they share the same data for locations as the map. Lastly location update delay while moving was reported the most as an issue by the participants even though it does not affect the gameplay it has impact on the players’ perception of their real-world movements in the game.
5.2. Interaction with PoIs

Regarding the second research question, the findings of the interview, and the location logs highlight the importance of PoIs for the players. In the design of the game, PoIs were selected based on their criteria and importance in the game map, and the points were ranked based on their priority and importance. The low priority points also gained importance by the game logic and mechanics to not be neglected. This design was implemented to tackle the issue of areas that contain fewer PoIs (Zielstra & Zipf, 2010; Juhász & Hochmair, 2017).

However, according to the interview feedback and the heatmap of the player interaction (See Figure 14), it is clear that players preferred the PoIs related to the physical world more than other PoIs, even though it was necessary to interact with other PoIs to be able to unlock the ones that are related to a physical place or object. This can be cause because of the attachment of the players to campus and elements that represents it (Oleksy & Wnuk, 2017). It is also in line with a study that suggests player movement heavily depends on the PoIs with significance that are related to physical objects (Laato et al., 2019a).

Some participants also were interested in interacting with virtual PoIs that are not represented by physical objects at their location. Three participants claimed that interacting with virtual objects, whether related to physical objects, changed their perception of the virtual and real worlds. However, the majority of participants highlighted the learning aspect of the interaction with PoIs. This in contrast with the result of Sifonis (2019) study, since three players started imagining virtual objects in the real world. However, the majority of participants did not mention imagining the virtual world in real world even though they liked the virtual objects on the game map, and they used the virtual map interface to learn more about their surroundings.

The players mentioned the reason to continue playing as learning about the campus and exploring and interacting with different elements on points they could interact. This is in line with the Alha et al. (2019) study that claimed interest in PoIs and progressing in the game while exploring the environment are the reasons that players keep playing. According to Söbke et al. (2017) the two motives for playing LBGs were discovering new spots and outdoor activities, this is partially in line with the findings of this thesis, since players did not mention outdoor activities as their motive, but they described exploration and game logic as the main motives.

The majority of participants mentioned that they would like to play on the whole campus and explore different areas; however, few participants claimed they prefer their usual daily route since they are familiar with the campus. Since the LBGs can affect the movement pattern (Karpashevich et al., 2016) even the players that prefer playing in their usual routes have to alter their movement to acquire the required items from different places. Their destination might not change but the path they travel can be affected by the game. This however can differ based on the mechanics and logic of the
game. In this study we included all the points in the game logic to a certain extent that player had to explore other areas.

The players suggested improvement ideas, and a critical suggestion was to use another map service instead of OpenStreetMap (OSM). The reason is that OSM is an open-source project, and sometimes the accuracy can depend on the quality of the data that contributors provide in mapping the geographical locations around them. This can lead to inaccuracies in the placement of points.

One suggestion was regarding the game's social aspect and incorporating social interactions in the game for the player, which is one of the main components of an LBG.

The other suggestions were related to the PoIs and the way they could present information to users, such as a building. This highlights the importance of PoIs related to the physical world by players.

Other feedback on improvement was related to graphics quality and adding Augmented Reality (AR) features to the game. However, a study on Pokémon Go players have stated that the AR feature is not used by majority of the player due to being slow and causing issues regarding the usability of the game (Laato et al., 2021).

The findings provide answers to the second research question and the sub-questions. Regarding the research question 2a, players preferred PoIs that are related to the physical world and provided information for the player. The findings related to the research question 2b highlighted that only three participants claimed that their perception of the real and virtual world was influenced by interacting with PoIs, therefore, the PoIs did not alter the perception of the majority of the players.

Previous studies have mentioned the characteristics of a well-designed PoI (Laato et al., 2019b). In this thesis all the PoIs were placed in safe and accessible areas for the players and the PoIs provided players with an experience for learning about their environment by interacting with PoIs. According to the findings, main elements for designing a PoI are representing the physical object that exists at the location of PoI and providing information specific to the physical objects that they are representing.
CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1. Conclusion

This thesis aimed to design an LBG based on the design criteria in the literature and implemented criteria-based PoI generation and distribution on the game map. The aim was to study the usability of the designed LBG. Additionally, it aimed to evaluate the interactions and attitudes of the players towards the PoIs in the game. It also aimed to study the virtual and real-world convergence from players' perspectives by conducting a qualitative analysis of their feedback on the game.

The game in this study was designed to allow players to explore the Middle East Technical University campus and learn about the campus and historical places by interacting with game elements in the virtual world while moving through the physical world.

The majority of studies in the field of LBGs are based on the physical movement, socialization, and visual aspects of LBGs, such as adding AR features, and these studies are mostly based on the data from the players of commercial games such as Pokémon Go. The other studies that implemented their design are mostly designed in a limited area and are focused on the narrative and storyline of the game. This thesis aimed to contribute to the existing literature by automatically generating PoIs based on the map data from OSM that represent the physical spots and also giving importance and priority to PoIs that contain less cultural and historical values by the game mechanics. The study's main contributions were the evaluation of usability and player interactions and experience with the PoIs by gaining empirical data from the players.

6.2. Design Suggestions for LBG Designers

Based on the findings of this thesis and existing literature, the following design factors are suggested for the future development of LBGs:

- Different map services can be implemented based on the requirements and scale of the game. Services such as Google maps can provide more accurate data as it
is updated regularly. On the other hand, services such as OSM are free to use and easy to implement but there is a possibility of inaccuracies at some areas since it is an open-source project and might not be updated regularly on all areas.

- The game objects and points on the map should be placed in safe areas that are accessible by the players. The PoIs in the private properties and restricted areas should be excluded by the designers as it can cause safety and privacy issues. To achieve this, a criteria-based method can be implemented to generate PoIs that are necessary for the game.

- Choosing a method for generation and distribution of PoIs depends on the game story and logic of the game. The games that are heavily based on the real-world spots should mostly utilize PoIs that are linked to the real-world objects. On the other hand, the games that do not prioritize the physical points can distribute PoIs randomly without any constraints towards physical objects.

- The game mechanics and game logic can be designed to incorporate the PoIs with less importance in the game especially in the areas that do not contain any PoI of significant value. It can also contribute to the gameplay as player travels between important PoIs.

- The radius of interaction might vary based on the game and the aim of that game. Although it is suggested that the radius should be big enough to provide smooth game play experience while walking, some PoIs require close distance interaction for gaining information and learning. The radius of interaction can be designed based on the characteristics of the certain PoIs.

- While using a criteria-based PoI placement by utilizing a map such as OSM, some local points that contain value for the inhabitants of that area can be missing on OSM data. The information about such places can be obtained from local sources to be added to a database. In a larger scale, the data of the points can be obtained by crowdsourcing method from the players.

- The location update delay can exist as a result of cellular provider coverage. To reduce the negative influence on players’ perception of the movement, the update distance of the location can be reduced however, this would result in extensive usage of battery charge of the mobile devices. A solution for this problem can be the implementation of an accelerometer sensor to visualize movement between location updates while moving.

- Although the location information and data of the users should be safe and not be accessible by other users, information such as scores and achievements can be shared. This can help the players be aware of their status among other players and compete against them.
6.3. Limitations

This study had limitations regarding the design and participants that could affect the robustness of the acquired data and results.

6.3.1 Limitations of Participants

- The participants for this study were selected based on convenience, and according to the demographic data of the participants, only two participants had prior experience with playing LBGs.

- The number of participants was limited to ten participants in this study. Having more people testing the game would have provided the chance to apply an exploratory mix-method analysis to test the validity of this finding with bigger sample size.

6.3.2 Technical Limitations

- The game was only published for Android devices, and therefore the data could not be acquired from players with iOS users. This might have highlighted problems that were more related to the device than the game usability since iOS devices have low diversity and better hardware and sensors.

- Due to time and technical constraints regarding the designing of assets, free-to-use assets and animations were used in the game.

- Not having access to information regarding the historical places in METU from a single and reliable source.

6.4. Future Work

Future work on this study can be done based on the participants' suggestions and findings from the analysis by adding new features to study this project from different perspectives.

- The multiplayer gameplay can be added for players to have social interactions.

- The game can be scaled to cover a larger area than the METU campus.

- The crowdsourcing method can be used to gather location data from players for places such as forests around the campus that lack data on OSM.

- Other map services can be used to have better accuracy and visuals of the environment.
REFERENCES


APPENDICES

A. Google Play Store Link for the MetuGo

B. A short video of the gameplay and in-game interaction.

https://youtu.be/_VXdeNubWuM
C. Interview Questions for Data Analysis process.

Demographic Questions:

1. Age:
2. Gender:
3. Education:
4. Game preference:
5. Time spent on playing video games:
6. Preferred platform to play games (PC, Console, Mobile):
7. Would you ever purchase video games?
8. Prior experience with playing location-based games:

Questions Regarding the Game:

1. Did you have any issues with creating account and starting the game?
2. Did you experience any difficulty with the accuracy of location service?
3. Did you find the game challenging or difficult at times? If yes, please explain. (e.g., Was it the physical movement, interacting with the point of interest or the other game mechanics).
4. How did you go looking for point of interests?
5. Did you find it easy to find the connection between different items that you collected?
6. Which items on the map drew your attention the most?
7. How interacting with different items on their real-world locations affected you?
8. What was the reason that made you keep playing and collecting the game items?
9. While interacting with an object in game did you pay attention to the physical building/monument?
10. Did you feel distracted from the game while moving between points of interest?

11. Did you play the game more than once?

12. Would you prefer playing on the whole campus map or the places that you commute daily?

13. Would you like to play it again and explore more places?
D. Permission Letter from Ethics Committee
E. Informed Consent Form

This research was conducted by Faraz Badali Naghadeh, master's student of METU Multimedia Informatics Department, and carried out under the supervision of Prof. Dr. Kürşat Çağltay. This form has been prepared to inform you about the research conditions.

What is the Purpose of the Study?

The purpose of the study is to measure several game metrics values based on the developed game and to analyze human computer interaction factors.

How can you help us?

In case of accepting to participate in our research you will be asked to answer demographic questions such as your age, gender, amount of time spent on playing games and whether you have prior experience playing a location-based games. The follow-up questions will be asked in the form of an interview after playing the game about your experience while playing and will be recorded.

How will we use the data collected from the participants?

Your participation in the research must be entirely voluntary. In the study, no identity or institution identifying information is requested from you. Your answers will be kept completely confidential and will only be evaluated by the researchers. The information to be obtained from the participants will be evaluated collectively and used in scientific publications.

Here's what you need to know about your participation in this study:

The research generally does not contain questions or practices that may cause personal discomfort. However, if you feel uncomfortable during participation due to questions or any other reason, you are free to not answer the question and withdraw any time.

If you want to learn more about the research:

At the end of the interview, your questions about this study will be answered. Thank you in advance for your participation in this study. For more information about the research, You can contact CEIT faculty member Prof. Dr. Kürşat Çağltay (E-mail: kursat@metu.edu.tr) or Faraz Badali Naghadeh from MMI department graduate student, (E-mail: faraz.naghadeh@metu.edu.tr).

I am participating in this study totally on my own will and am aware that I can quit participating at any time I want/ I give my consent for the use of the information I provide for scientific purposes. (Please return this form to the data collector after you have filled it in and signed it).

Name Surname Date Signature

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F. Debriefing Form

First of all, thank you for your participation in our research.

This research was conducted by Faraz Badali Naghadeh, master's student of METU Multimedia Informatics Department, and carried out under the supervision of Prof. Dr. Kürşat Çağiltay. The purpose of the research you have participated in is to analyze the game metrics by asking you to play a location-based game developed during this study and measure usability and human-computer interaction factors. According to the literature, location-based games have been used in numerous fields, both in academia and commercially. However, location-based games have been popular among players. They have shown a potential to be implemented in non-commercial fields such as education. The elements that make these games enjoyable and more user-friendly have been a research area in academia. This study aims to implement this genre of game on the campus of METU and analyze the outcomes and behaviors of the players. For this, you were first asked to answer demographic questions. Later on, you were asked to answer a set of questions in an interview about your experience with different metrics of the game.

The information obtained from this study will only be used in scientific research and writing. For the research to progress correctly and the findings to be reliable, we kindly ask you not to share detailed information about the study with other people you know who will participate in the research. Thank you again for participating in this research.

You can contact the names below to learn the results of the research or to get more information.

prof. Dr. Kürşat Cagiltay (kursat@metu.edu.tr)

Faraz Badali Naghadeh (faraz.naghadeh@metu.edu.tr)

As a volunteer contributing to the study, you can forward your questions or opinions about your participant rights or ethical principles to the METU Applied Ethics Research Center.

e-mail: ueam@metu.edu.tr
TEZ İZİN FORMU / THESIS PERMISSION FORM

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TEZİN TÜRÜ / DEGREE: Yüksek Lisans / Master ☐ Doktora / PhD ☐

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