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Development and Usability of a Location-based Game

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Abstract. Location-based games (LBG) incorporate players' location as their main game element. Therefore, they are played in the physical world by turning every place into a playground. Due to the pervasive nature of LBGs, usability evaluation can differ from the other game genres. This study aims to develop an LBG based on a university campus by implementing a criteria-based method to populate the map and distribute points of interest. Ten participants tested the developed game, and a qualitative analysis was conducted via holding interviews with each participant to evaluate the game's usability and identify usability issues specific to the developed LBG and LBGs in general. The findings show that participants showed a positive attitude towards the game; however, multiple issues were identified regarding the LBGs. These usability issues are the inaccuracy of the map in representing the points, the radius of interaction, and location update delay.

Keywords: Location-Based Games, Usability Testing, Human-Computer Interaction

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 with 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 [1]. For the last two decades LBGs have been a subject of study in 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 subcategory of pervasive games [2]. Since they aim to converge the real and virtual world for the players, the terms such as mixed-reality [3], hybrid-reality [4] 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 [5], movement [6], cartographical knowledge [7] and social interactions [2, 8] 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 locations 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 [9]. 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. Commercial games are mostly playable everywhere around the world and use more advanced systems such as having a large database containing all the points in every place. In contrast, for research based and individual projects collecting such amount of data and maintaining it can be quite time-consuming and costly.

Considering the definition of play by researchers such as [10] and [11] 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 Objective of the Study

This study aims to design and develop 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) [12]. 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 and real world will be analyzed by usability testing.

Specifically, this paper makes three contributions:

1. A criteria-based automatic POI-generation pipeline for OSM data in campus-scale LBGs.
2. An ecological usability evaluation method that integrates spatial movement logs with post-play interviews.
3. A set of empirically grounded design guidelines and a usability framework for future LBG developers.

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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?

2 Related Work

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" [13]. LBGs became popular after US government made the GPS signal data available for public usage on 1 May 2000 [14].

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 [8]. However, a study [1] argues that the game and players do not turn the city into the playground, on the contrary, places can have playful characteristics.

Several different terms have been used for LBGs. The term mix-reality games are suggested by researchers [2, 3] 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 [4]. These terms have been derived from the virtuality continuum [15] 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 [1].

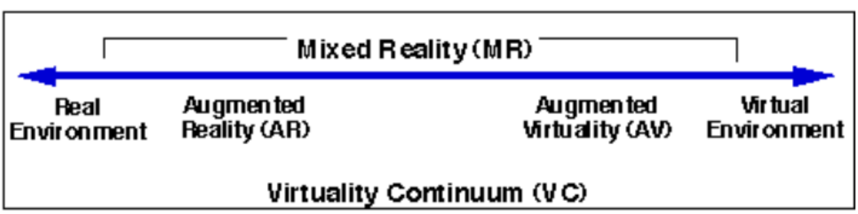

Fig. 1. Virtuality Continuum [15].

In a study LBGs are categorized into physical, local, global and glocal [2]. 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 [8].

Player movement to areas not defined for gameplay can expand the magic circle while playing pervasive games [16] challenging and often violating the characteristics of the playground such as being confined and well-defined. According to the study [16] 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[8].

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 [9].

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 [17] to the gameplay [9]. 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 [18].

PoIs can be generated in two distinct ways. One method is using algorithms to create procedural [19] and random points. The second method is manually creating points using crowdsourcing and generating PoIs by designers and developers [20].

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 depends on the algorithms used [9]; however, manually created PoIs can generally achieve more robust results [19]. 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 [9].

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 [7]. Location-based games are shown to automatically support cartographical and navigational practice if they contain a navigational interface based on real-world maps [7].

The characteristics of LBGs are suitable for serious games [21]. Serious games are kinds of games that are not designed solely for the purpose of entertainment [21]. LBGs can be used as serious games [21] for learning. A study [5] categorizes 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. They enrich the relationship of players with their surrounding environment and create an attachment to the places around the players [23].

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 [24]. 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 [24]. This type of behavior can harm the players physically and socially [25].

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 [26]. Since games are highly interactive, Human-Computer Interaction (HCI) related issues should be studied. Games and productivity software such as map-based navigation tools are different in the sense that in games user interface should not distract the user [27]. Microsoft in 1997 implemented usability evaluation methods for the first time in development of games [27].

One study [28] suggests 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. Furthermore, a study [29] 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 game developers.

Although the user interface is emphasized in defining usability, the game platform, gameplay and the type of the game should also be considered since they are related to each other [30]. 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 [31].

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 [32].

3 Methodology

3.1 Research Design and Design Criteria

This study aims to design and develop an LBG based on the design criterias in literature such as safety, engagement and PoI generarion and selection and conduct a usability test to evaluate its usability. Qualitative data analysis method [33] 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.

We derived five core design criteria for MetuGo from prior LBG research:

1. Playability & Learning Motivation: Embed educational content into real contexts to promote exploration and active learning, following guidelines for location-based learning games [5].
2. Mobility and Spatial Interaction: Stimulate physical movement and campus exploration via game logic and PoI placement, based on hybrid-reality frameworks [14].
3. Cognitive and Emotional Engagement: Select PoIs tied to meaningful or historically relevant locations to bolster narrative coherence and motivation, informed by mixed-reality experiences [42].
4. Safety and Accessibility: Exclude unsafe or inaccessible zones to protect player well-being, drawing on PoI-quality analyses [9].
5. Usability Heuristics: Provide clear UI feedback, low learning curve, and minimize GPS-induced frustration, grounded in established game-usability guidelines [28], [29].

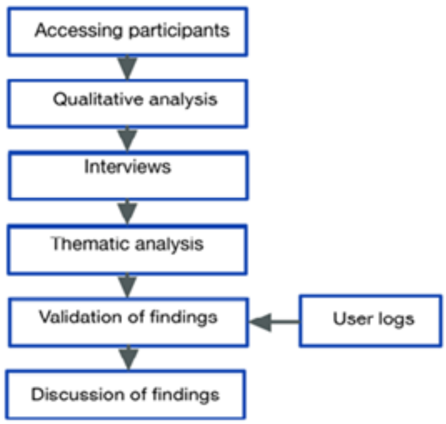

Fig. 2. Usability Research Methodology.

3.2 Developing MetuGo

The development of the game was completed in three iterations including one major change in the fundamental design of the game at the first stage. The goal of this study was to develop a location-based game customized for the Middle East Technical University (METU) campus, with the aim of investigating usability issues and player interaction with Points of Interest (PoIs). While prior commercial games (e.g., Pokémon Go, Ingress) rely on massive, curated PoI databases, these systems are proprietary and not adaptable to local academic settings. Furthermore, many academic studies in the literature rely on manually placed PoIs, which makes replication difficult and increases the workload during development.

Our objective was to implement an automatic and criteria-based PoI generation method using open-source data from OpenStreetMap (OSM), allowing us to customize

PoI selection based on the unique spatial and cultural features of our campus. This also ensures reproducibility and scalability in future LBG projects. By grounding the system in real-world coordinates and filtering for meaningful, safe, and gameplay-relevant PoIs, we aimed to explore how such design decisions impact player navigation, engagement, and perception of space.

First Prototype. The first prototype aimed to develop a 3D blueprint of the campus (See Figure 3). 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, this prototype was discontinued following the recommendation of a domain expert with over 20 years of experience in game development and prior consulting on commercial projects involving physical movement. The expert noted that due to missing data—particularly regarding building height and structural details, the resulting 3D environment lacked spatial fidelity. More importantly, it deviated from the intended focus of the project, which was to use the map primarily as a navigational and interactive interface rather than building a detailed 3D reconstruction of the campus. Although OSM maps can be updated manually, the project's scope was not about contributing to cartographic databases, but rather about designing and evaluating a location-based game grounded in our campus setting, with an emphasis on the role of Points of Interest (PoIs) in shaping user interaction.

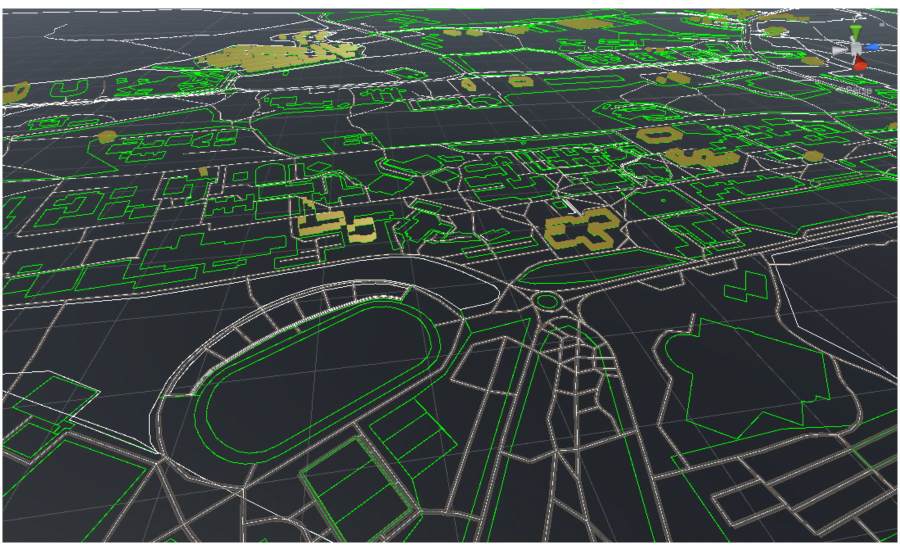

Fig. 3. Screenshot of the first prototype.

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 [34]. The data could be lost by uninstalling the game or, in the case of an application crash, that could result in losing the data 6 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.

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 [35]. 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 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 (See Figure 6).

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 4). 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.

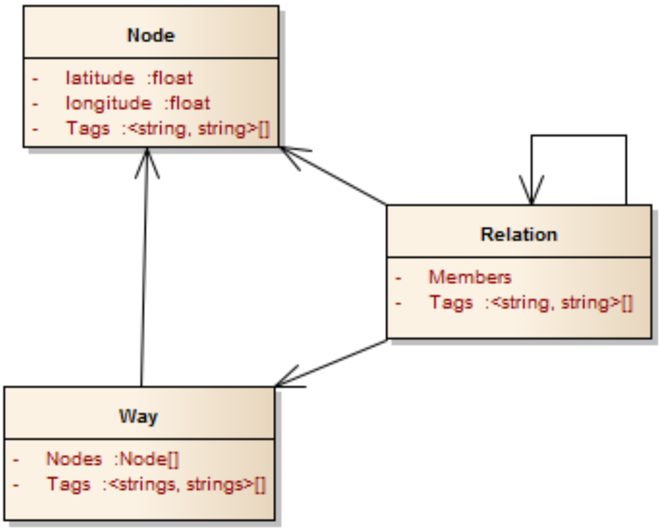

Fig. 4. OSM data model [36].

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 [37] 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 PoI generation process was guided by a automated pipeline that included both filtering and prioritization steps. First, we excluded unsafe and restricted zones such as the rector's office, administration buildings, and dense natural areas based on tags in the OSM XML. Then, we parsed the remaining data and ranked PoIs according to a priority logic inspired by the design criteria (e.g., engagement, safety, symbolic relevance). For example, monuments were considered high-priority locations due to their cultural value, whereas sidewalks and cycleways were categorized as low-priority but still valuable for encouraging movement across campus.

In addition, important locations that were absent in the original OSM dataset — such as animal feeding zones that are socially meaningful to the campus community — were added manually via a custom CSV file. These CSV entries included lat-long coordinates and relevant tags, and were parsed to dynamically place the points in Unity.

This hybrid approach of automatic parsing and manual enhancement ensured both spatial accuracy and contextual relevance**.**

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 [38] 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 crashes while running the app, and also it helped to load the objects on the map from the data stored on the database (See Figure 5).

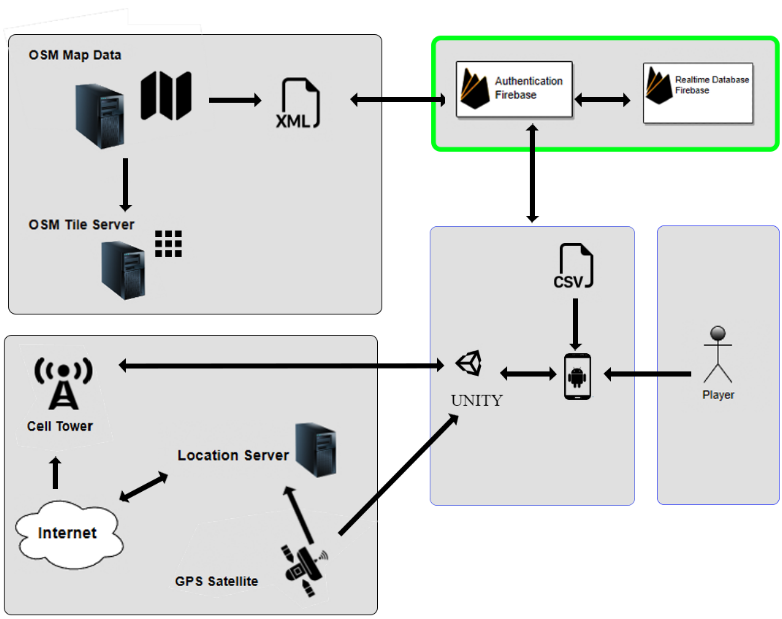

Fig. 5. System architecture.

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

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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.

Fig. 6. Screenshots of the game.

As shown in Figure 6, the game includes loot boxes as chests that players have to unlock them to acquire items to interact with the PoIs, such as monuments and animals. These items are saved in the players' inventory 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 specific action or collect a particular item that is required for the interaction with PoI. The user can access the instructions 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.

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.

Table 1. Demographic data of the participants.

No	Age	Gender	Game Preference	Gaming Duration	Preferred Platform	Prior LBG Experience
P1	29	Female	None	None	PC/Mobile	No
P2	30	Male	MMORPG	3 Hours	Mobile	No
P3	30	Female	Hyper casual	7 Hours	Mobile	Yes
P4	21	Female	None	None	PC	No
P5	27	Male	FPS	14 Hours	PC	Yes
P6	26	Male	Sport	2 Hours	Console	No
P7	30	Male	Action-Strategy	14 Hours	PC	No
P8	29	Male	FPS	1 Hour	PC/Mobile	No
P9	21	Male	FPS	14 Hours	PC	No
P10	27	Male	None	None	Console	No

3.2 Participants

In this study a single usability 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 was 21 to 30. 3 of the participants were female while 7 were males. The education level of 6 participants was B.Sc. or equivalent and 2 participants had Ph.D. or equivalent. Lastly, 2 participants had M.Sc. or equivalent.

3.3 Data Collection

The snowball sampling method [39] is used to access participants. The information about the study was shared on online communities and associations in the university, and the link for downloading the game was provided. Ethical approval from METU Human Subjects Ethics Committee with confirmation number 0378-ODTUIAEK-2022 was obtained before conducting this study.

3.4 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 Table 1.

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 participants 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.

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.

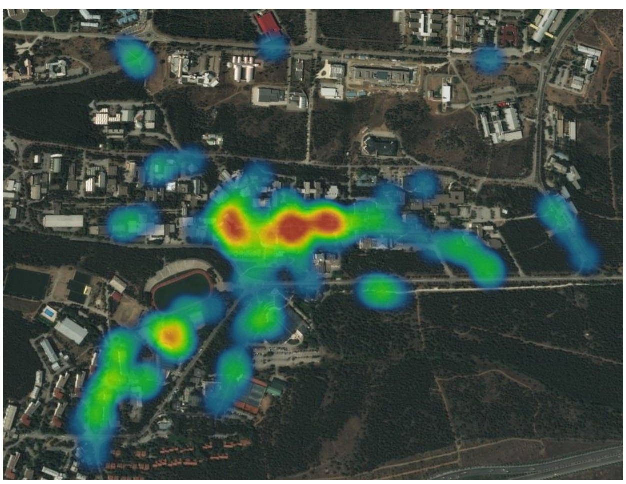

Fig. 7. Heatmap of the players' interaction with PoIs.

The heatmap of the campus (See Figure 7) 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.

3.5 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. After each gameplay session, participants were interviewed individually using a structured set of ten predefined questions designed to evaluate their experience with the game, including aspects such as user interface, gameplay mechanics, interaction with Points of Interest (PoIs), and awareness of their surroundings. Interviews lasted approximately 15–20 minutes and were conducted either in person or via video call, depending on availability. Most sessions were audio- or video-recorded with participant consent; in some cases, real-time notes were taken when recording was not feasible.
The responses were transcribed into a structured table format in a text editor and analyzed manually using a deductive thematic approach. The themes were predetermined based on the interview structure; however, overlapping responses between questions were expected and handled during coding. In some cases, additional remarks emerged during the open-ended closing questions, which were grouped under a dedicated "Suggestions for Improvement" theme. Coding involved identifying the frequency of key patterns across participants and mapping relevant quotes to each theme. To strengthen validity, interview data were cross-checked with in-game logs and heatmaps to compare self-reported feedback with actual behavior. 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 accounts 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 interest (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 interest 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 interest 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 to 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)"

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 questions 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)"

One participant stated that sometimes they were distracted while moving between points because of the surroundings. Participants were also asked about their focus on real world objects while interacting by virtual items that represent 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)”

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 where 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 in areas that cover their daily routes. Six participants mentioned that they would like to play the game on 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.

4 Discussion

4.1 Usability of the MetuGo

By combining spatial movement logs with structured post-play interviews, this ecological evaluation method contributes a novel way to assess how location-based mechanics shape usability in LBGs—moving beyond UI-only tests to capture real-world engagement.

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. The usability evaluation method in this study, which relied on post-experience interviews and gameplay logging, contributes to the broader landscape of usability evaluations in LBGs by focusing not only on interface and interaction design but also on how location and movement-based mechanics influence player comprehension and engagement. Unlike conventional usability tests that often isolate UI components, this approach integrates spatial dynamics, enabling a more ecological assessment of how players navigate and perceive their physical and digital environments together.

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. This supports Criterion 1:

Playability & Learning Motivation and Criterion 5: Usability Heuristics, showing that clear controls foster exploration and low cognitive load.

Considering the definition usability in [40], 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. Since, usability in LBGs should provide safe gameplay and easy to learn environment for the players [32], all the items and PoIs on the map were placed in the areas that are safe to play and PoIs in dangerous areas were excluded based on their OSM tag information. This finding directly addresses Criterion 4: Safety & Accessibility, confirming that filtering OSM tags yields a safer play environment.

This placement strategy was guided by predefined design criteria—including safety, accessibility, engagement, and symbolic significance. For instance, removing dangerous locations like forests and administrative zones addressed the safety criterion, while ensuring interaction with monuments and well-known student locations satisfied engagement and relevance. The design criteria thus shaped both the content and structure of the game world, ensuring that usability was evaluated not just in terms of interface clarity, but also in alignment with spatial and experiential design values.

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 [41], 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. These issues highlight a tension in Criterion 5: Usability Heuristics, and suggest a guideline: location-update latency should stay below 2 s in dense PoI zones.

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 [42] 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. This also points to Criterion 5, demonstrating the need for an optimal interaction radius that balances precision with accessibility.

The importance of UI and the fact that it can make the players not want to play again is emphasized in [31]. 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 [43].

Regarding the first research question, the findings highlight a few usability issues related to the LBGs. The accessibility of 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 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.

Furthermore, the discussion around usability in this paper directly intersects with the special issue theme of map-based interaction. In MetuGo, the digital map is not merely a UI element but the core interaction modality. The integration of GPS tracking, real-world PoI alignment, and spatial exploration positions map-based interaction as a meaningful and playful mode of user engagement. These results suggest that map-based interaction in LBGs can simultaneously support orientation, immersion, and goal-directed behavior, which can inform future design frameworks for such systems.

These findings suggest that usability evaluations of LBGs should extend beyond traditional UI assessment to also include evaluation of location responsiveness, real-world alignment of virtual elements, and how map interfaces support or hinder physical exploration. By identifying key pain points—such as delayed location updates and interaction radius sensitivity—this study contributes to shaping a usability framework tailored specifically for LBGs that rely on real-world movement and spatial awareness.

4.2 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 [44,45].

However, according to the interview feedback and the heatmap of the player interaction (See Figure 7), 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 caused because of the attachment of the players to campus and elements that represent it [23]. 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 [9].

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 [46], 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 with. This is in line with the study that claimed interest in PoIs and progressing in the game while exploring the environment are the reasons that players keep playing [43]. The main two motives for playing LBGs were suggested as discovering new spots and outdoor activities [47], this is partially in line with the findings of this study, 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 [24] 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 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 [18]. In this study 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.

The findings reinforce the role of the digital map not merely as a background or interface layer, but as the core medium of interaction that guides movement, object discovery, and player immersion. The seamless blending of virtual content with map-based spatial cues forms the essence of the gameplay experience in MetuGo, aligning with broader discussions on map-centric game design. As such, this study directly contributes to the theme of the special issue by exploring how map-based interfaces mediate real-world exploration and digital engagement.

5 Conclusion and Future Work

5.1 Conclusion

This study aimed to design an LBG based on the design criteria in literature and implement 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 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 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 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 study aimed to contribute to existing literature by automatically generating PoIs based on the map data from OSM that represents 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.

5.2 Design Suggestions for LBG Designers

Based on the findings of this study 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. 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 real-world spots should mostly utilize PoIs that are linked to real-world objects. On the other hand, the games that do not prioritize physical points can distribute PoIs randomly without any constraints towards physical objects.
- Game mechanics and game logic can be designed to incorporate PoIs with less importance in the game especially in 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 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 are 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 updated 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 could 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.

5.3 Limitations

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

5.3.1 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 the campus testing the game was time consuming. 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. Additionally, due to time limitations and iterative constraints, the design and prioritization of PoIs were researcher-driven rather than co-designed with users. This may have influenced how players engaged with game content and limited the diversity of player strategies.

5.3.2 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.All participants were already familiar with the campus, which may have reduced the novelty and spatial learning potential of the experience. This limits the generalizability of the findings, particularly for new users exploring unfamiliar environments.

5.3.3 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.
- Researcher–driven PoI selection: Due to time and iteration constraints, PoI design and prioritization were conducted by the research team rather than via co-design with end users, potentially biasing engagement findings.
- Not having access to information regarding the historical places in the campus from a single and reliable source.

5.4 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 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.

CRediT author statement.
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