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Article

Location Hunting Game: Developing an Application to Promote Gameful Hybrid Machi-aruki Town Exploration

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Abstract: Previous research has established the relevance of digital tools in participatory processes of urban planning and design. Nevertheless, the debate about the role that these information and communication technologies (ICTs) play within the participatory process, with respect to established practices and methods, and in relation to community building and public space, is still ongoing. The purpose of this paper is to present the design and development of a participation tool that attempts to combine physical and digital forms of interaction with public space and the community in the context of an essential initiation practice in Japanese participatory planning, called machi-aruki (town walking or walking tours). This tool, named the Location Hunting Game (LHG), employs location data as a medium to connect digital and physical realms, and was developed in a broader theory-driven research endeavor that explores the potential of location data in collective urban planning and governance. This article presents the concepts and objectives of LHG, the game design, the interface design, the prototyping process, the technical specifications, and a summary of the preliminary results of a trial study. The results provide insights into the potentials and limitations of the current prototype and development challenges, and conclude with future research steps.

Keywords: machi-aruki; local knowledge; location-based technologies; information and communication technologies (ICTs); gameful design; community development; participatory urban design and planning; location-based liquid voting

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1. Introduction

1.1. Machi-aruki: A Participatory Practice of Building a Common Ground

1.1.1. Definition of the Terms Machi-aruki and Machizukuri

Machi-aruki (まち歩き) can be literally translated as 'town walk' or 'city walking'. Yukiko [1] uses the term 'machi-aruki type of walk' to connect this practice to *machizukuri*, which literally means 'making the city'. The term machi-aruki encompasses a participatory approach, whereby people experience a collective and shared process through the action of walking [1]. The translation of the term machi-aruki into the English language might in some cases lead to the loss of hidden and culturally dependent meanings. For that reason, the original term, machi-aruki, will be used herein.

The second term, machizukuri, can be translated as 'town building' or 'community development' [2]. It refers to a grassroot approach to urban planning and community revitalization, emphasizing local participation and collaboration among residents, businesses, and local governments. The 1960s mark the beginning of a shift in urban planning in Japan from top–down government-led planning toward a participatory approach [2]. This nationwide movement emerged from the attempt of citizens to cope with environmental, economic and social risks [3]. Gradually, methodologies and practices of machizukuri started to emerge [2]. Today, machizukuri is established as a set of activities conducted

at the neighborhood level, involving citizens in the improvement of their living environments. Within these participatory practices (mainly workshops), machi-aruki emerged in the 1980s, as an initiation step of machizukuri workshops [4].

1.1.2. Steps and Goals of Machi-aruki Practices

Matsuura et al. [4] explain that there are three steps in a standard machi-aruki: (1) Town exploration or inspection: in a small group of less than 10 people, participants identify local issues and mark them down using notepads or paper maps after discussing the issue and sharing it with the group. These walking strolls are guided by facilitators, who may be members of neighborhood associations, local authority, or teachers/researchers [1]. (2) Summary or record phase: in a workshop format, the participants mark down their findings in a large collective map, to which multiple machi-aruki groups can contribute. They can also summarize their findings in written format [1]. (3) Review: With the help of a facilitator, the participants present their issue identification results and discuss them in a dialogue with the other groups. Figure 1 illustrates an example of a standard machi-aruki, whereby participants inspect the city and record their observations.

Figure 1. Example of a typical machi-aruki tour (source: ud.t.u-tokyo.ac.jp; accessed on: 24 August 2021).

Machi-aruki aims at adopting a participatory and deliberative approach to the issue identification and goal setting in the early stages of decision-making and urban transformation projects [4]. Machi-aruki is also employed for civic learning objectives. For instance, to educate citizens (including students of various ages) about disaster prevention, whereby getting to know the local areas where people live and collectively recognize the issues that need to be solved, is a vital first step in knowing how to cooperate in preventing risks [1].

Furthermore, Yabu et al. [5] categorize the objectives of machi-aruki type of tours into three categories: (1) Investigation, such as the creation of accessibility maps for people with disabilities; (2) Sightseeing: to learn about the history and culture of an area; and (3) Interaction: by socializing with fellow participants and with the local community. In comparison with other participatory methods, machi-aruki tours are perceived as 'enjoyable' processes of participation, whereby citizens get to take part in 'light' deliberations and discussions that do not involve high stakes, which constitutes an introduction to the next phases of decision-making in urban planning. The enjoyment factor in machi-aruki lowers the hurdles of participation and invites diverse groups to take part in it [4] (p. 62).

1.1.3. Walking Tours as a Participatory Planning Practice in Other Contexts

In the global context, walking tours are also employed as a tool in urban planning. Andersen and Balbontín [6] describe 'Commented Walks' as a participation tool for obtain-

ing contextualized information and increased opportunities of interaction. Recently published research by Custers et al. [7] employs participatory walks as a method to include local knowledge in future neighborhood planning. Additionally, a review of grey literature shows that walks, whether urban or rural, have been used as a tool by local authorities, community associations, or private institutions, to raise awareness about local issues. For instance, Urban Walks is a series of urban planning-oriented walks that were organized by Habitat 3 across different countries, inviting participants to learn about urban interventions in their cities. Jane's walks is a project of free neighborhood walking tours inspired by Jane Jacob's legacy on the importance of local knowledge held by the residents, in improving living environments. Another example is Transect walks, a participatory method that allows urban planners to get familiar with a local area in a simple and inclusive way compared to community meetings.

1.1.4. The Use of ICT Tools and Location-Based Technologies in Machi-aruki

According to a recent review of the use of information systems in machi-aruki [5], the role of ICT tools can be summarized in three application forms: (1) to confirm the walking route in advance; (2) to easily collect and upload location information during machi-aruki; and (3) to store, organize, and visualize location-based information for future reflection activities.

For instance, Matsuura et al. [4] used mobile phones and GPS technology to design a participatory issue identification system for machi-aruki in a coastal area. Miura et al. [8] developed an application to map the physical accessibility state of public spaces. Through a machi-aruki, volunteers explore urban space and generate location-based data (photos, text, or sound) about the accessibility conditions. In both these projects, the tools developed can also be used in consequent participatory workshops as data visualization platforms. With a different approach, Nakano et al. [9] developed an AR application that projects old photographs of locations, which allows participants to appreciate the history and transformation of public spaces while physically visiting them.

According to a study by Matsuura et al. [4], the collective physical exploration of public space has high learning effects and generates better interactions between participants. ICT tools, on the other hand, provide efficacy in data collection and organization and can expand the reach of machi-aruki to a national scale, by allowing participants from different machi-aruki tours to contribute to the mapping of urban issues in a single digital platform, without restrictions in terms of immediacy or locality.

Beyond the use of location-based ICT tools for the efficiency of data collection and sharing in machi-aruki, the aim of the present article is to allow people to participate online through a gameful digital tool in addition to physical participation. Machi-aruki invites people to view their everyday environment in a new light, to acquire knowledge about the local culture, history, and issues [1]. Through design exploration, we attempt to expand these goals to the digital realm in a 'hybrid machi-aruki', while still encouraging the physical presence in public space as being an essential component.

1.2. Hybrid Forms of Participation in Urban Planning

The internet penetration in everyday life and the increasing digital capacity of citizens are making the use of digital tools in participatory planning more and more possible. Technology-supported participatory urban planning can open new possibilities and forms of participation that are flexible in time and space, and enjoyable. Investing time to travel and attend a face-to-face meeting at a specific timeframe, remains a non-trivial barrier to participation [10]. Online participatory tools (OPTs) [11], e-participation, and mobile participation [12] are terms used to describe the implementation of ICT tools in participatory urban planning and design, to complement and enhance the conventional participation methods [11] (p. 163) [13] (p. 9), reduce the access barrier [14], and diversify the groups of participants [15] by attracting new stakeholders such as the youth [11] (p. 172).

Nevertheless, the physical connection to local areas and face-to face contact remain essential even in smart and digital cities [16]. Tayebi [17] states that online communities

have a grounding in physical locations in one way or another, the same way that physical communities, like a neighborhood local community, employ telecommunications in their interactions.

In this regard, location-based technologies are promising innovative tools that connect digital and physical realms, as global positioning systems (GPS) are becoming more and more available and embedded in everyday lives. Public Gratification Palace [18], for instance, is a framework for a hybrid participatory urban planning and design process, that combines social media like platforms with geo-tagging functions, requiring users to be physically present in public space to initiate conversations online, creating as a result chances of interaction with one another in a public space. In a similar approach, the present research takes interest in how location data can connect everyday realities to urban decisions in participatory urban planning.

1.3. Local Knowledge in Participatory Planning

The relevance of citizen participation in planning lies in the incorporation of local knowledge into planning decisions and interventions [19,20]. Local and spatial knowledge is of significant importance to urban planning and design because it incorporates, not only geographic information, but the experiences of people and the meanings they attach to their living spaces [21] (p. 1). It includes 'contextualized, targeted, useful information about local characteristics and issues' [11] (p. 163), and is often characterized as soft, subjective and experiential, as opposed to expert knowledge [22].

There exist various methods in participatory planning and design to collect and/or map local knowledge. In the Japanese context, machi-aruki is one of these methods. It not only aims to allow experts to discover people's preferences and gather local knowledge to complement their own, but machi-aruki is also a learning experience for the participants themselves, by enriching their local knowledge and raising their awareness of local issues.

1.4. Gameful Design and Gamification in Participatory Urban Planning and Design

The development of digital tools for participatory spatial planning, is increasingly required to consider the distracting digital ream people are exposed to, where a manifold of platforms are competing for their attention and time [23] (p. 2). To do so, the design of worthwhile and/or enjoyable experiences [24] (p. 3) of participation becomes increasingly relevant. The success of participatory tools and methods relies on the continued voluntary participation and engagement of people, which brought us to expand our research to gameful and motivational design.

Gameful design or gamification is considered one of the user-oriented ways of improving planning support systems in the context of smart cities and collaborative/participatory planning [25]. Geertman and Stillwell [26] argue that planning support systems should be appealing to the participants and enjoyable to use, especially because people are expected to volunteer and invest their time and energy to participate in urban planning. Previous gamification research in participatory urban planning supports the potential of gamification in creating playful experiences of socio-spatial learning and the positive effects it has in boosting motivation [27]. Nevertheless, gamified platforms can easily become too complex for participants to use [28]. This highlights the difficulty of implementing gamification in practice, especially in urban planning, where the issues discussed are complex and require long-term engagement. As many researchers have been careful to note, gamification strategies do not automatically and always create better and more participation.

Gamified digital tools in participatory urban planning can be distinguished by the role they play and their design approach. For example, in relation to the role, Tan [29] defines 'Generative city games' as games that result in design propositions which ended up being implemented in reality, while Devisch et al. [30] describe 'civic learning games' as games that support the collective reflection on spatial issues. With respect to the design approach, Deterding et al. differentiate between serious games which are full-fledged games for non-entertainment purposes, and gameful design, whereby some game elements are

incorporated [31] (p. 11), although the boundaries between these categories remain blurry. The Location Hunting Game (LHG) presented here can be characterized as a civic and spatial learning game, whereby the aim is to interact with and learn about local places. It is designed as a full-fledged game, except for the voting part (see Section 3.1 for details), where less game elements are implemented.

Furthermore, this article aligns with the concept of meaningful inefficiencies [32] in the design of civic systems and tools, which advocates for creating opportunities of play and messiness. These playful systems promote increased civic learning and foster civic action [32]. Additionally, LHG was inspired by how the potential of location data is creatively displayed in location-based games, such as Pokemon Go, and locative media scholarship in general [33]. In the field of game design, games using mobile and GPS technologies such as urban games, location-based-games, and hybrid reality games, transform public spaces into a playground, inviting players to explore new areas in their cities [34] (p. 610). LHG is developed in the context of participatory urban design and planning, and is specifically inspired by the location-based game 'Geocathing' [34] (p. 616). However, the subject of interest is public space in and of itself. In this research, we attempt to design a gameful experience of machi-aruki, whereby the 'serious goal' is to learn about local spaces and communities, and create a common ground between participants through the sharing of knowledge and social interaction.

1.5. Aims and Objectives

Consensus building is highly challenging in participatory decision-making. The conflicts of interests and tensions are an integral part of the negotiation process. What this project tries to do is look at how to build a common sense of familiarity with the local area and the people before reaching advanced phases of decision-making. To do so, this research takes interest in geolocational technologies that connect the internet and communication networks to socio-spatial urban issues.

The Locating Hunting Game is a machi-aruki game inspired by treasure hunting, whereby participants/players are invited to 'hunt locations'. Through a map-based interface, participants are invited to guess the right locations of photos taken by others in their machi-aruki. While exploring public spaces, participants are asked to notice any element they like or find interesting, which could include issue identification, and share it in the game by taking a photo and commenting on it. In addition, online participants can engage in a simple voting process as a civic learning experience. This voting process is based on a conceptual framework of location-based liquid voting, which was introduced in a previous publication by the authors [35] and inspired by the work of Sakai [36]. This voting model will only be briefly explained in the present article. The question this research project tries to explore is whether the adopted gameful design will attract players and motivate them to engage with the LHG app and the explored local area. In this article, we will focus on a specific question: How does this LHG prototype fulfill machi-aruki goals through a gameful and hybrid experience of spatial and civic learning?

A recent systematic review by Ataman and Tuncer shows that tool development and design is one of the missing parts in participation tools and urban intervention research that requires further investigation [37] (p. 13). The aim of this article is to provide a detailed report of the design and development process of LHG, including the conceptual design and specifications derived from literature review, the technical specifications, the game design, the prototyping process, and finally a summary of the preliminary results of a trial study. The analysis related to the assessment of LHG after the trial study is out of the scope of this article. Insights on the challenges faced in developing LHG and testing it will be presented, along with recommendations and planned future research steps.

2. Materials and Methods

This research is a design exploration that seeks to test ideas by bringing forth an artifact or a product that in itself becomes a contribution to an ongoing societal discussion [38]. This project is part of a research endeavor that combines theory-driven design-based methods, which, so far, resulted in the current prototype of the Location Hunting Game. The development process was carried out in two phases and generated two prototypes. A first functional prototype implementing essential parts of both design and functionality, was tested internally within the laboratory by few students, but mainly by the first author and a collaborator, to identify potential technical problems and evaluate the prototype based on reflections and observations. These observations were fed back into the development of a second prototype, which is the current version of LHG. This prototype was tested in a trial intervention study, which took place in the rural area around the university campus and invited the campus users to try LHG.

Machi-aruki Using Bicycles: An Experimental Aim of the Current Version of LHG

As part of a larger collaborative research project that aims at testing new technologies, we explored how we can employ an electric bicycle with embedded GPS data collecting sensors (Figure 2) as the machi-aruki mobility medium. Although the Japanese term machi-aruki includes in its meaning the act of walking, i.e., 'aruki', we argue that riding the bicycle as a mobility medium does not exclude LHG from being a machi-aruki experience. That is, riding the bicycle is a flexible form of mobility that allows for exploring and examining public spaces at varied paces. Machi-aruki as a practice is different from daily life walking, whereby participants in machi-aruki consciously observe and re-discover the familiar spaces they live in. In the same way, we believe that riding the bicycle with the purpose of discovering public spaces does not undermine the purpose of machi-aruki.

Figure 2. The electric bicycle used to explore urban space in LHG. Once turned on, the bicycle starts recording and uploading GPS logs to an online server. During the trial study, participants were covered by traffic accident insurance, in accordance with the research ethics guidelines. (Source: Authors).

Riding an electric bicycle for machi-aruki has benefits such as enjoyment, ease of mobility, extended travel distances; and shortcomings, namely the limitation of participants who explore public space to those who want or can ride a bicycle. Nevertheless, considering that riding bicycles is part of the Japanese culture, we decided that this research project would be a suitable opportunity to experiment the use of bicycles in participatory urban planning. Originally, LHG was planned with the expected supply of few of these electric bicycles, so that participants could physically explore the local area as a group, similarly

to conventional machi-aruki tours, or individually. However, due to unexpected circumstances, only a single bicycle could be delivered. This impacted the conceptual design of LHG and adjustments had to be made accordingly. Nevertheless, the current version of the app still includes the main design concepts and objectives.

3. Results

This section describes the development process of the Location Hunting Game (LHG), including the conceptual design of the application, the technical specifications, the interface design process, and the gameplay. In addition, it presents a description of the trial study conducted, and a summary of the preliminary results. A thorough analysis of the trial study data is a work in progress at the time of writing this article and is planned to be published in future work. Challenges and limitations are discussed to inform app development by others.

3.1. Conceptual Design of LHG

LHG is a multiplayer network game based on content creation by the participants and is intended to promote local knowledge acquisition via the exploration of public space. Figure 3 illustrates the socio-technical system of LHG. As a machi-aruki experience, gameplay is initiated when someone rides the bicycle and starts exploring. They then share geotagged photos (with comments as an option) of places, landscapes, activities, or objects of interest. Players online can then view the bike route on a map, in addition to the photos taken of which the locations are hidden from them. The challenge is to guess or hunt these locations. When a player correctly guesses a photo's location, or when the time is out, this image is added to a list of content (photos and comments) in the voting screen. Here, players can vote on which of these locations are the best in their opinion. As mentioned earlier, the voting is a location-based liquid process [35]. Being location-based indicates that the voting power is weighted by location tokens. In other words, the more players ride bicycles and physically explore public space, the more location tokens they earn. These tokens are used by the players to vote and express their opinion on which locations they like best. The liquid aspect of the voting refers to the availability of two voting options: (1) direct voting, whereby players can express their opinion by directly voting on a location; and (2) delegation, whereby participants can give their vote, partially or fully, to others, as a process of social interaction and collective intelligence [35]. This way, the physical presence in public space is encouraged in LHG and it is what generates the interaction that happens in the digital realm.

Conceptually, LHG is designed as a civic learning process that invites participants to make decisions informed by local knowledge. This local knowledge is not only acquired by participants and reflected in the voting process, but it is also collected through the app, in the form of geo-tagged data and citizen-generated content (preferences, opinions), which could potentially inform urban planners and local governments and investors (Figure 3).

Gameful design or gamification in this research is adopted as an approach to the creation of enjoyable experiences, pertaining to the belief that humans have a natural inclination toward playfulness in its diverse forms and varying degrees. In this respect, LHG was designed as a serious game that provides logic for interactions with digital platforms, but without compromising emphasis on the content, that is, learning about the locality and participating in a collective activity. The gameful approach was carefully thought out in relation to the outcomes of participating in urban planning via such a game. Poplin [28] highlighted the difficulty and importance of differentiating between serious opinions and gameplay outcomes. In this respect, we adopted a gameful design that does not influence or incentivize the voting actions, which aligns with the approach taken by Thiel, Ertiö, and Baldauf [27] in regards to democratic actions in a gamified participation tool. As a result, earning local knowledge about the explored area was gamified through a location hunting game format. However, the voting for the best locations was not linked to the game outcomes to avoid bias.

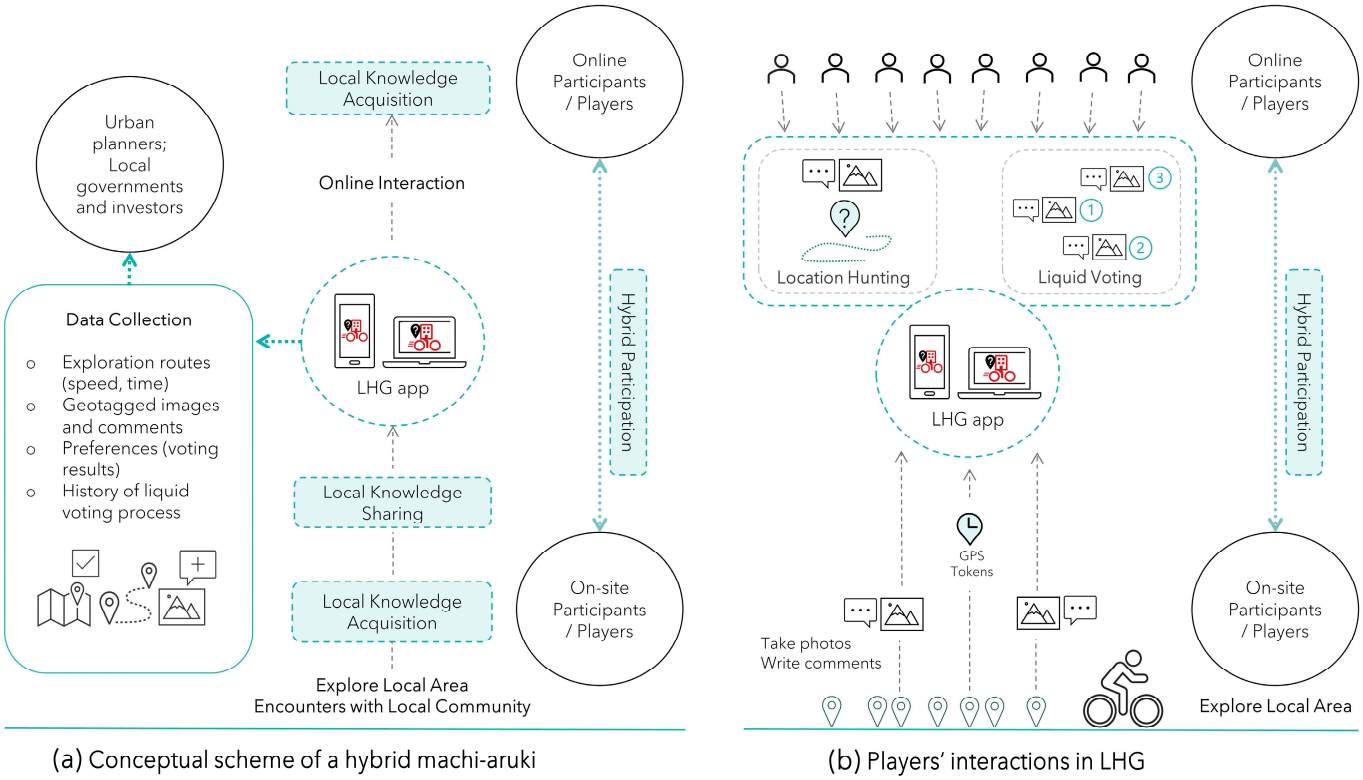


Figure 3. Scheme of the socio-technical system of LHG: (**a**) the conceptual scheme of a hybrid machi-aruki; (**b**) the interaction between the players in LHG; the numbers (1), (2), and (3) in the liquid voting activity, indicate the ranking of the locations in the voting results.

Furthermore, data visualization is also part of the design of LHG, whereby participants interact with mapped information of the bike routes. This information was visualized in a way to provide clues for players to correctly guess the hidden locations. And so, one of the objectives of LHG is to investigate to which extent the adopted data visualization was understood by the players/participants and informed their guessing actions. Albeit LHG contains simple tasks, the ultimate objective is to contribute to the improvement of data visualization in participatory urban planning tools. Table 1 provides a summary of the conceptual specifications of LHG and their implementation through a location-based system.

Table 1. Specifications of LHG enabled by the implementation of a location-based system.

Specification	Description
Machi-aruki and commentary	○ Direct experience of space ○ Using the bicycle and mobile phone GPS sensors ○ Accuracy of location tracking ○ Simplified calculation of location tokens
Hybrid participation	○ Unsynchronous participation ○ Online and on site ○ Social interaction ○ Anonymity as an option
Gameful design	○ Urban exploration ○ Riding the bicycle ○ Game creation (self expression via generating personalized game content) ○ Location hunting challenge ○ Playful Interface design

Table 1. *Cont.*

Specification	Description
Data sharing and visualization	○ Map-based interface ○ Use of data as game hints/elements
Location-based liquid voting	○ Weighted voting power ○ Delegation ○ Collective decision-making ○ Transparency of results ○ Flexible online voting
Crowdsourcing	○ Urban data collected that could benefit in understanding preferences and behaviours.

3.2. Technical Specifications

During the development of LHG, we hired two different developers for the first and second phases. Timeframe and budget meant that there were conceptual and technical design features that we desired but had to compromise on. We chose to develop LHG as a web application to allow for both android and iOS users to participate in the game. When riding the bicycle, players use their smartphones to take photos and record the GPS coordinates, but they can use any personal device to hunt locations or vote online. The bicycle routes are recorded via the bicycle itself. When turned on, the bicycle uploads GPS logs every 10 s.

LHG uses Heroku as a deployment platform and Mapbox for map visualizations based on Open Street Map. The GPS logs are stored in a cloud server, and location tokens are recorded by calculating the number of these logs. The images taken by players are stored in an AWS server. No personal data are collected from the participants personal devices, which was clearly communicated to them in the trial study via consent forms. Overall, the data recorded by LHG app include timestamped geospatial data (bicycle routes, speed, geo-tagged images, and their comments); and timestamped interaction data (attempts to guess hidden locations, voting actions, and voting results).

Because LHG employs a single bicycle, we implemented a ride mode system to identify the rider of the bicycle and allocate location tokens to their right owner. Participants/players simply mark the start and end times of their bike ride in the application and this timeframe is correlated with the GPS logs stored in the bicycle server.

3.3. Prototyping and Interface Design Process

As mentioned above, two prototyping phases took place, which resulted in prototype 1 (P1) and prototype 2 (P2) (Table 2). P2 brought major changes to the user interface by improving the design and adding further instructions. It also included significant improvements in the efficiency of the code, the processing of GPS logs, and the efficiency of map visualizations, compared with P1. No iterations were made in terms of the gameplay between P1 and P2, except the addition of the possibility of uploading more than a single photo per bike ride for the online 'hunt locations' game. P1 only allowed a single photo per bike ride to be part of the game. This improvement enriched the content and game creation in LHG. Table 2 below shows the development of the interface design, from mockup, to prototype 1, then prototype 2. Four main interfaces of LHG are described in detail: the home screen, 'Hunt Locations', 'Vote for Best Locations' (the delegation tab), and the voting results. The table describes the improvements made from P1 to P2 in terms of technical performance, UX-I, data visualization, and app design elements.

Table 2. Interface design process of LHG. The figures of P1 and P2 are actual screenshots of the application interfaces; P2 is the current version of LHG.

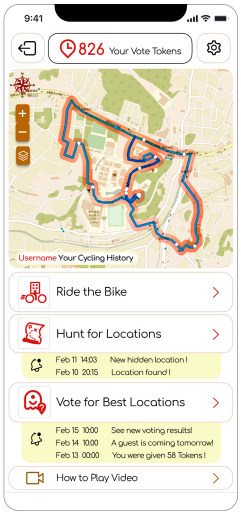
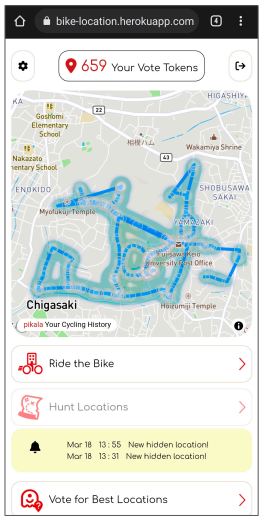
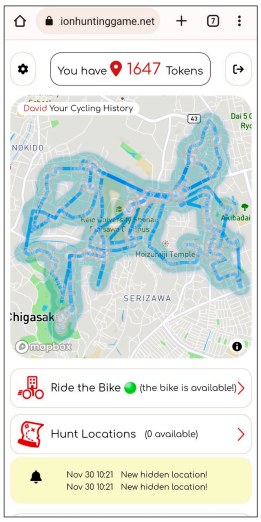
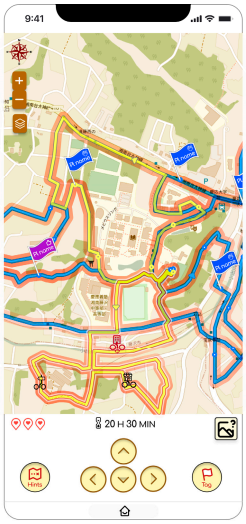
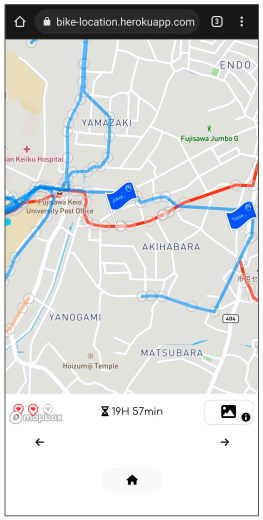
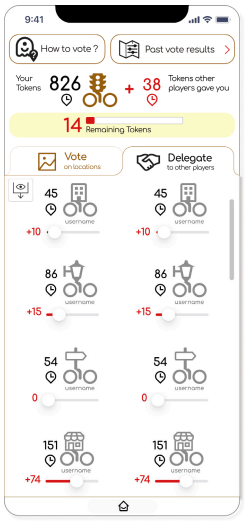
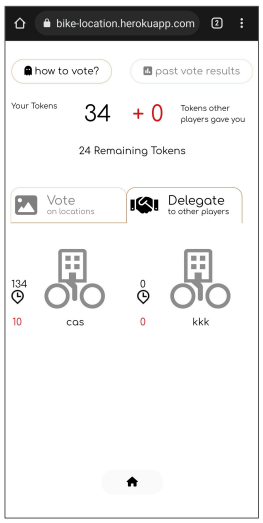
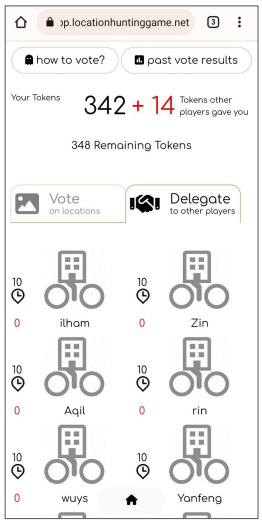
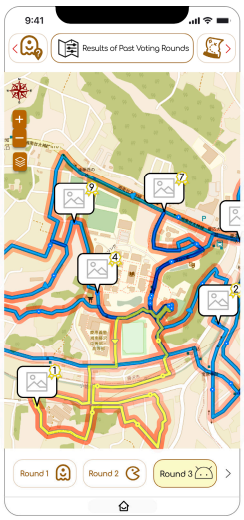
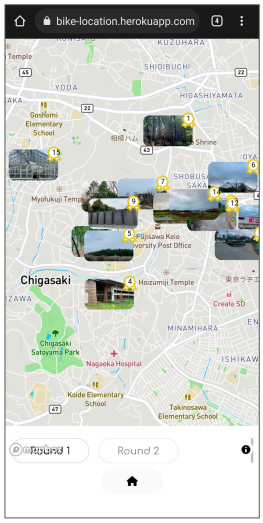
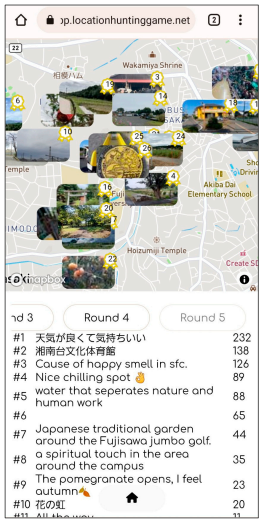
	Mockup	Prototype 1 (P1)	Prototype 2 (P2)	Improvements from P1 to P2
Home Screen				Technical performance - Delete duplicates in GPS logs. - Optimize the code for data visualization. UX-I - Add a green/red light to indicate the real-time availability of the bicycle. - Add information about the number of live hunt location games.
Hunt Locations				Technical performance - Delete duplicates in GPS logs. - Increase the guessing range to compensate for the inaccuracy issue of mobile phone GPS when taking photos (especially for a rural area). Data visualization - Bring the active game routes (the red and orange routes) forward. - Add a heatmap showing the overlap of location points. UX-I - Add the hidden location's image and comment in the same interface as the map instead of a pop-up window. - Add a 'how to play' button showing a map legend (the gameplay in P1 was only explained in a tutorial video). App design elements - Allow the option of taking more than one photo per bike ride thanks to the improved interface of hunt locations. P1 only allowed for a single image to be included in hunt locations. Additional images, if taken, would only appear on the voting screen.

Table 2. *Cont.*

	Mockup	Prototype 1 (P1)	Prototype 2 (P2)	Improvements from P1 to P2
Voting (Delegation tab)				App design elements - Give 10 tokens to all players when they initially sign up to the game. The goal is to allow players who only participate online to still be able to join the voting.
Voting Results				Technical performance - Optimize map visualization. Data visualization - Bring forward the images in the order of the voting results. UX-I - Add information about the voting results: ranking of the locations and total tokens allocated to them.

3.4. The Gameplay in LHG

3.4.1. Riding the Bicycle

As illustrated in Figure 4, the gameplay in LHG is initiated when a participant/player rides the bicycle to explore urban spaces and takes photos to share with online players. However, participants do not have to ride the bicycle to play LHG. They can choose to play exclusively online, by interacting with the game content that bicycle riders share from their machi-aruki tours. The availability of a single electric bicycle in this project created a challenge of how to identify the bike rider and allocate the right GPS tokens to each player. To solve this issue, we adopted a ride mode solution, whereby participants click a start button before riding the bicycle, and an end button to mark the end of their ride.

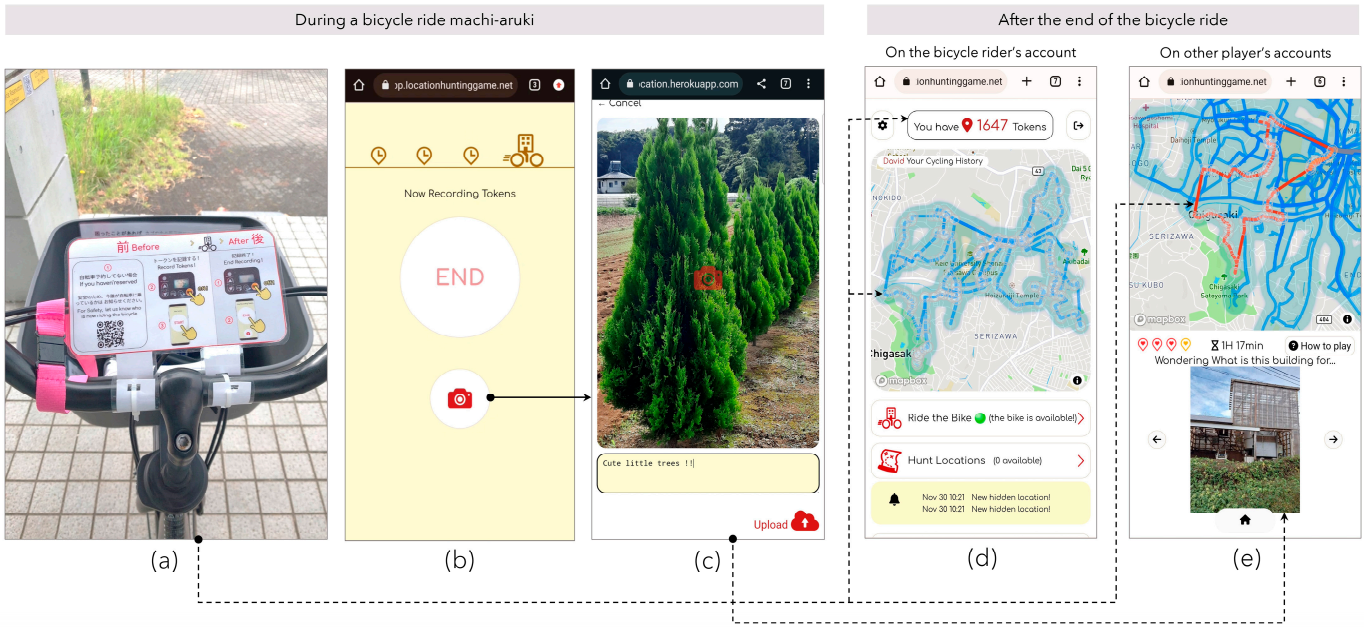


Figure 4. (**a**) Instructions on the bicycle about the ride mode; (**b**) ride mode in progress with the camera button to take photos; (**c**) photo and comment upload; (**d**) the home screen showing the players a map of their bicycle rides and the count of their location tokens; (**e**) 'Hunt Locations' interface displaying one photo taken by another player and highlighting the bicycle ride during which it was taken. (Source: Authors).

While on the ride-mode, participants could take photos of what interested them using a camera button and write a comment if they wish to. To record the spatial coordinates of a photo, the plan was originally to only retrieve a timestamp from mobile phones and match it with the closest GPS log in time, registered by the bicycle. However, we observed after tests that there are consistent gaps in the recording of GPS logs by the bicycle system, resulting in missing chucks in the routes visualized on the maps. Which means that in the case where the location of a photo corresponds to one of these gaps, the solution of matching timestamps to identify the photo's location cannot be viable. Consequently, we opted for employing mobile phone GPS to record the coordinates of photos, despite the fact that this method added extra steps for the players (allowing the browser and the web app to access the phone's location).

After every bicycle ride, the route taken by a player is visualized on a map on their home screen, and the number of GPS points logged is added to the count of location tokens earned. Simultaneously, the bicycle route and the photos taken are displayed on the 'Hunt Locations' game interface (see Section 3.4.2). The locations of the photos are hidden from online players, and the challenge is to guess where they were taken.

3.4.2. Hunting Locations

To hunt locations online, players interact with an interface that shows the photo taken and the comment attached to it, in addition to a map displaying all the bicycle rides of all the players so far in the game. As shown in Figure 5, the map is overlaid with the following:

- **Blue routes:** indicating all the previous bike rides completed within the game, where the challenge of the hunting locations is over.
- **One red route:** indicating the selected active game route, within which the photo shown on the interface was taken somewhere. This route serves as an indication of the range within which players should hunt the hidden location of that photo. On top of the red line, GPS points are visualized as transparent white circles, making the overlap of these circles identifiable. The distance between these circles is an indication

of the speed of the bicycle, and the overlap is an indication of a stop, which could be made to take a photo.

- **Orange routes***:* if available, indicate other simultaneously active game routes. They signal the players of the existence of other photos that they can hunt. By using the arrows left and right on the interface, players can move from one photo to another. By doing so, the orange routes turn red accordingly.
- **Blue flags**: indicating the photos of which the locations were successfully guessed by a player whose username is written on the flag.
- **Purple flags***:* indicating that no player could guess the location successfully, in which case, the username of the bicycle rider who shared the photo is displayed on the flag.

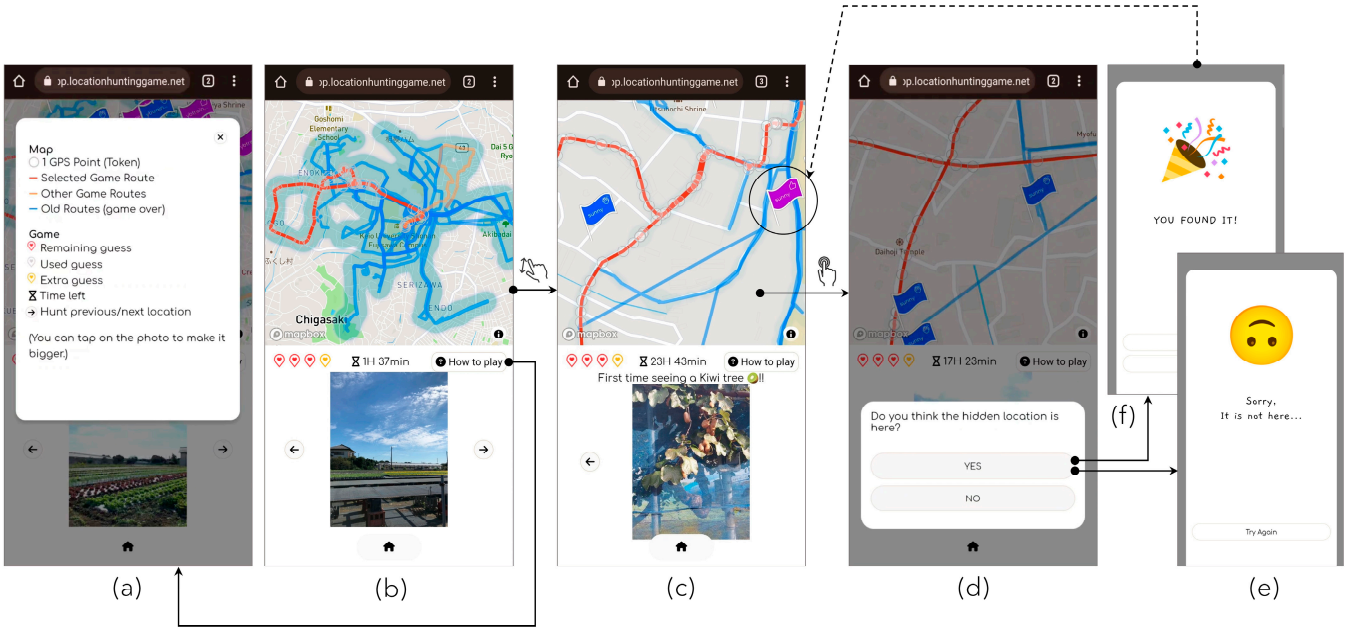


Figure 5. User interface of the hunt locations. (**b**) Hunt location interface, the map's data visualization employs mapbox. Under the map, on the left, the number of heart icons indicates the guessing chances left, next to it is the time left to guess that specific photo, and the button 'How to play' displays a legend (**a**) explaining the meaning of the map's visualization and the interface icons. Clicking on the photo shows a pop-up window with a larger image. To hunt the hidden locations, players can zoom in the map (**c**) to explore and examine the spatial information, then tap to place their guess. A pop-up window (**d**) asks the player to confirm their guess. Playful feedback (**e**), (**f**) informs the player whether they successfully guessed or not. (Source: Authors).

It is important to note that the participants were only given information about the meaning of the data visualization. They were not given any interpretation of what it could indicate. Specifically, the fact that the overlap of the transparent circles (representing GPS points) could be where the photo's hidden location is, was not communicated to the participants in the trial study. One of the objectives of this project is to investigate whether this data visualization will be understood, and how it will be interpreted by the participants.

3.4.3. Voting for Locations

The voting activity in LHG is conceptualized as a simplified opinion survey. The players are invited to express their opinion on which of the locations or images they think are the best among all the locations shared in the game. This activity allows the participants to learn about the local area and each other's interests, firstly by examining the things or places others chose to take a photo of, and secondly by viewing the voting results. This voting system is based on location tokens, whereby players/participants are encouraged to physically move through public space. The more the players ride the bicycle, the more

GPS points they generate, hence the more tokens they accumulate, allowing them to have greater influence on the voting results.

As illustrated in Figure 6 and described in its title, the liquid voting system allows for both delegation and direct voting. The intended purpose of delegation, in this prototype of LHG, is to create a social interaction between the participants, as well as indirectly introduce participants to a voting model (liquid democracy). However, the meaning of delegation within this specific activity (voting for best locations) could be interpreted in different ways. Again, we did not provide participants with any interpretation as we are interested in how they will understand the concepts of voting tokens and delegation.

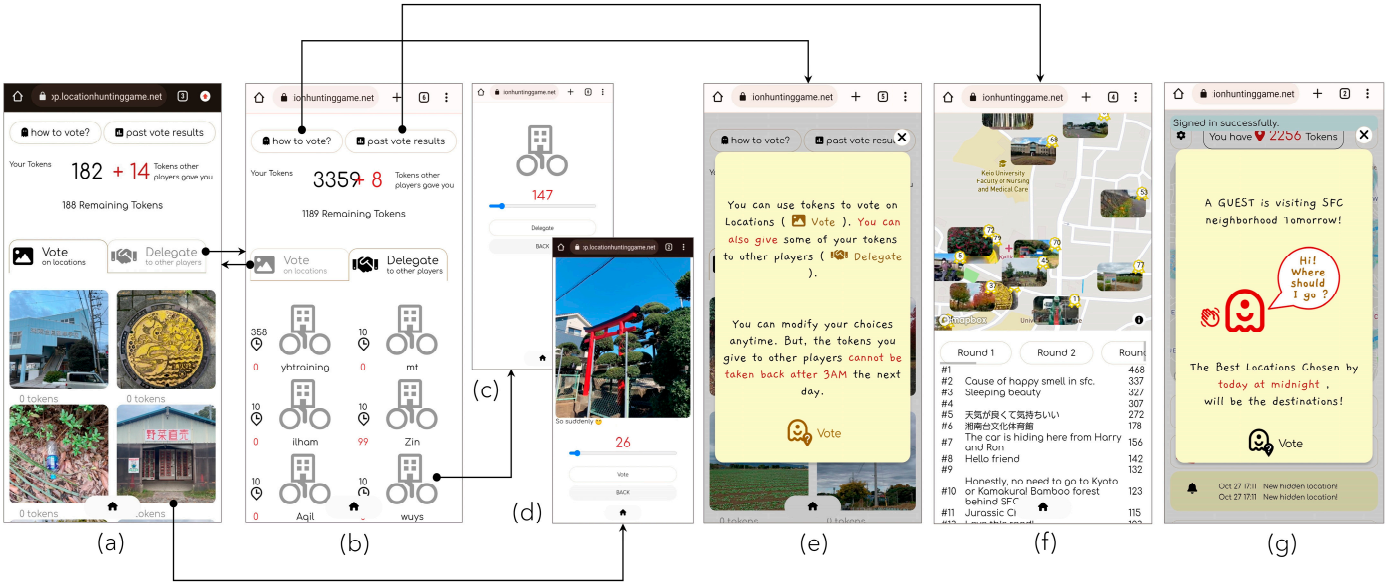


Figure 6. (**a**) The voting interface when accessed from the home screen, containing two tabs, one for direct voting (**a**) and the other for delegation to fellow players (**b**). The interface displays the number of tokens earned by riding the bicycle (in black) and the number of tokens received from others through delegation (in red). The remaining tokens help the player keep track of how they distribute their tokens. Clicking on the images or the profile icons allows the player to allocate tokens (**c**), (**d**). Instructions on how to vote are provided in (**e**). The voting results are shown on a map (**f**). Every voting round is notified by a playful message (**g**). (Source: Authors).

The voting interface displays the total amount of tokens participants can use to vote and keeps track of the remaining tokens they have left after allocating some of them. To organize the voting activity, we chose to create voting rounds of 3 days each. At the end of each round, the results were calculated and shared on a map. Since the players can change their votes anytime until the end of the voting period, a 24 h cycle was set for token delegation to avoid errors that occur when players vote using tokens received from others, then these delegations get cancelled. Finally, as a playful approach, a storytelling element was added to announce the end of each voting round, as illustrated in Figure 6.

3.5. Summary of Preliminary Results from a Trial Study

Considering the testing phase LHG is currently at, the main target group was the young generation, also described as the 'digital natives' [39]. Digital natives are accustomed to using ICT technologies. They also gradually introduce it to their communities. The trial study took place at a university campus, where participants are mainly university students. The reasons for choosing such a setting are to study how digital natives will evaluate the tool, while interacting with the rural locality surrounding their main study destination, which is shown in Figure 7. Since 2022, on-campus classes and activities are gradually being allowed after the COVID-19 pandemic restrictions, while several classes are still held online.

Figure 7. Aerial view of the campus area where the trial study of LHG took place. (Source: Google Earth).

The trial was designed as a voluntary participation process, simulating the participation protocol in urban planning. We recruited our participants through an active community outreach, using various media including a website, posters, and a tutorial video, inviting all the users of the campus, including faculty members and employees, to play LHG. Participants could use their personal devices and the web app did not require any downloading. To sign up to LHG, participants needed to provide an email address and create a password and a username for their accounts. The bicycle was placed in a covered outdoor spot next to a bus stop and in front of the main campus building. This space had posters, instructions, and QR codes, inviting passersby to join the game.

Participants were asked to (1) fill a pre-survey linked with the participation consent form, (2) play LHG freely within the trial period, and (3) fill a post-survey distributed via e-mail. After the end of the trial, we further conducted semi-structured online group discussions, with seven participants who volunteered to take part in it. Those who completed the pre- and post-surveys and made at least one action in the game were given a 1000-yen gift card. All communication media were provided in both Japanese and English languages.

During a period of 6 weeks (October–November 2022), a total of 65 players joined the game, of which 17 were not active. Moreover, 22 participants made 38 bicycle rides, with a median duration of 56 min. Thirty participants made 326 attempts to guess the hidden locations online (median = 4), of which sixteen participants could correctly guess at least once. For the voting of the best locations, 39 participants made 375 voting actions (median = 4). A total of 216 photos were taken in LHG, of which 137 had comments attached to them. At the time of writing this article, the data analysis of the self-reported data and logged data is still ongoing. The next phase of the research will assess participant engagement with and evaluation of LHG. This trial study was approved by the research ethics committee of the university.

4. Discussion

The following discussion section reports preliminary observations about the unfolding of the trial study, and describes some of the challenges, mainly the occurrences of technical glitches, faced throughout the process. However, this section does not intend to assess LHG. With that said, the following discussion provides insights into the design and testing of LHG that could benefit other researchers in developing similar participatory location-based gamified tools.

The trial was designed as an intervention in an uncontrolled environment (a university campus), inviting all its users (hundreds of students, faculty, and employees) to try

a gamified application. Hence, despite the number of participants that ended up joining LHG not being large, we consider this outcome a part of the results of this study. The reasons behind this outcome could be related to the application design, study design, or external circumstances. Moreover, we engaged in collecting rich qualitative data through group discussions and written feedback in addition to the quantitative data, to ensure a complementary analysis and evaluation. It is also important to note that, due to the nature of research investigation which relies on the collection of data, participants were asked to fill in an entry form, containing a consent from and a pre-survey. Even though it takes only a few minutes to fill in this form, we believe that the participation entry to LHG could have been smoother without this extra step.

Using a bicycle as a machi-aruki medium distinguishes LHG from previous ICT tool applications in machi-aruki. In a sense, the bicycle acted as a situated medium, attracting people's attention, and inviting them to participate in situ or online. Nevertheless, we suspect that having to ride that specific bicycle might have limited the chances of having more people participate physically in LHG. Some participants were inquiring whether they could use their own bicycles to ride, alone or with their friends. In addition, some participants misunderstood riding the bicycle as mandatory to be able to participate in LHG. Conversely, other participants found the assisted bicycle convenient to move in the rural area around the campus and combined their machi-aruki trips in LHG with running their personal errands. Overall, LHG could also be implemented using the GPS of personal mobile devices, allowing participants to use their preferred mobility form, in which case, privacy issues will need to be addressed.

Despite the availability of extensive informative material (website, posters, tutorial video) on how to play LHG, some participants did not or chose not to view the instructions. At this stage, LHG did not have extensive instructions on the app to guide the participants step by step. In P2 (Prototype 2), we included a legend explaining the data visualization scheme, after realizing from the feedback of some participants that they did not understand how to hunt locations. As a result, the simplicity and clarity of the tool is an important factor in encouraging the adoption of new forms of participation.

While the tool's gameful approach and the UX-I were given priority in the development of this prototype, the GPS tracking methods were also improved and tested, especially with the use of an electric bicycle. On the technical level, the GPS data collection and accuracy were two of the main issues faced and required corrections and improvements constantly during the trial intervention. The electric bicycle used in LHG is equipped with a tracking device that starts sending GPS logs to a cloud server once the bicycle is turned on. The accuracy of the bicycle tracking device was acceptable. However, we faced issues of missing data (failure in uploading chunks of GPS routes to the server) and unpredictable delays in the upload that would result in uncompleted bike routes on the hunt location map. The routes would eventually be completed after a certain period (minutes on average). Furthermore, the Smartphone GPS, which is used to collect the coordinates of the photos taken during machi-aruki, proved to have a low accuracy, especially android devices. This could also be related to the fact that the area where the trial took place was rural. These issues affected the gameplay in the hunt locations, whereby players would correctly guess the location of an image and still get a wrong answer message. We fixed this issue by manually correcting the GPS coordinates, taking the bicycle route and the map as a reference.

Additionally, we acknowledge that the issue of the digital divide and accessibility to ICT tools persists despite the increasing spread of the internet and communication tools. And so, we do not consider hybrid tools such as LHG a replacement of the current practices of machi-aruki, but rather as a complementary and supporting tool for the existing face-to-face and digital processes. Some people are less comfortable with face-to-face meetings or cannot afford to join them. Others prefer offline interaction and the social energy it generates. In this regard, albeit being out of the scope of this project, one of the potentially interesting features that could be added to a machi-aruki game app, such as LHG,

is a function that allows for the organizer or facilitator of the participation process, to change the following parameters in the game mechanics: the voting rounds, the guessing timeframe, the number of guessing chances, etc. This approach, especially in relation to the time dimension, could allow for an adaptability of use for both asynchronous and synchronous activities, in various participation settings (workshops (online and offline), collective machi-aruki tours, etc.).

Finally, while machizukuri activities, specifically machi-aruki discussed in this article, have developed with a strong connection to the specific Japanese context, they still share similarities with various community-based approaches in different countries around the world [2] (p. 233). The design and development of LHG took into consideration the cultural context of Japan, the rural setting of the trial study, as well as the characteristics of the target group, which is digital natives. This influenced the design decisions and the gameful approach adopted. However, considering that the connection of communities to their living environments and local areas is a fundamental element in various societies and cultures, we believe that LHG can be adopted in other contexts. Modifications in the app functions and the degree or type of the gameful design will be necessary to cater to the preferences and motivations of citizens, and support positive and diverse participation experiences for different groups of people, in their particular contexts [40] (p. 19). Moreover, the results of the usage of the app in the participation process will also vary from one community to another, as technology fulfils different roles for different communities.

4.1. The Added Value of LHG

Machi-aruki serves as an entry point for participation in urban planning and design, by familiarizing people with the local environment. LHG is an attempt to explore how to extend this entry to online forms of participation by creating a gameful hybrid machi-aruki experience. On the one hand, inspired by location-based games and grounded in the practice of machi-aruki, one of the initial design concepts was to bring people to public spaces physically, and invite them to explore it and sense it, to live in it for some time, as a process of acquiring knowledge about it. On the other hand, online users of LHG are also participants in machi-aruki. They interact with spatial information and other participants in a gameful system, through hunting hidden locations and taking part in a voting process. Finally, LHG incorporates a location-based liquid voting model, with the aim of producing empirical data about the interactions and implications of this novel collective decision-making scheme. To summarize, Table 3 provides a comparison of LHG with some of the previous similar machi-aruki ICT tools, developed in the contexts of urban planning and crowdsourcing, with the aim of assessing and/or learning about public spaces and the local community.

Table 3. Comparison of LHG with similar machi-aruki applications in terms of specifications, objectives, and study format, as reported by the respective authors.

Characteristics	**Umiaruki Issue Identification App [4]**	**Physical Accessibility Sharing Smartphone App [5,8]**	**Web AR App [41]**	**Disaster Information Tweeting and Mapping System (DITS/DIMS) [42]**	**Location Hunting Game (LHG)**
Objective	Data collection for future decisions in urban planning To promote deliberations	Efficiency of data sharing with people with disabilities	Learn about visited areas and the local community	Review the town in terms of disaster prevention and mitigation, and promote self and mutual help by citizens	Promote the learning and sharing of local knowledge and build a common ground

Table 3. *Cont.*

Characteristics	Umiaruki Issue Identification App [4]	Physical Accessibility Sharing Smartphone App [5,8]	Web AR App [41]	Disaster Information Tweeting and Mapping System (DITS/DIMS) [42]	Location Hunting Game (LHG)
Purpose of employing ICT tools	As a motivation for citizens and a data collection/ organization system	Data collection, organization, and visualization tool	Providing additional information for people during machi-aruki	Facilitate the posting and sharing of disaster-related information on Twitter	Enable a hybrid from of participation in machi-aruki and create a gameful experience
Gameful approach	No	No	No	No	Yes
Location tracking method	Smartphone GPS	Smartphone GPS	Smartphone GPS	Smartphone GPS	Electric bicycle's GPS, Smartphone GPS
Testing format	Workshop format	Workshop format	Workshop format	Workshop format	Short-term Intervention
Number of participants in trial studies	15	10	10	22	65
Date and location	2 September, 2010 Odaiba Seaside Park	Tokyo	Saturday, 16 April, 2022, 13:30–16:00 Hino City	6 October 2018 Makomanai area, Minami Ward, Sapporo City	6 weeks (between 10th Oct and 30th Nov 2022) Endo, Fujisawa City

4.2. The Desired Outcomes of LHG

As reported in this article, we attempted to create a hybrid machi-aruki experience by employing location information as the medium. Via physical and digital interactions, LHG was designed with the aim of achieving similar outcomes to machi-aruki, while extending the reach of this practice through time and space. Table 4 summarizes the expected outcomes and how they are embedded in the interactions of participants within LHG.

Table 4. The desired outcomes of LHG and how they are incorporated in the system interactions.

Desired Outcome	LHG Interactions in	
	The Physical World	The Digital World
Local/spatial knowledge learning	- The direct experiences of and physical interactions with space. - Taking photos of public space, with the purpose of making others guess their location; promotes attention to the details of the public space and the activities that take place in it.	- Guessing the locations of photos and interacting with visualizations of machi-aruki routes in a gameful way. - Interacting with the images on the voting interface.
Place attachment	- Personal physical experience.	- Interacting with other players' perspectives and experiences of public space.

Table 4. *Cont.*

Desired Outcome	LHG Interactions in	
	The Physical World	**The Digital World**
Sense of community	- Observing people's activities during machi-aruki and potentially interacting with them.	- Interacting with content created by other players. - Noticing other players' usernames on the map. - Voting via delegation.
Civic learning		- Participating in the voting process.
Enjoyment	- Exploration experience. - In this prototype, riding the bicycle.	- Playing a game. - Simplified tasks.
Crowdsourcing	- Collecting collective data about people's opinions and behaviors to inform planning.	

4.3. Future Research Steps

In the Japanese machizukuri culture [2], the processes by which people get together to improve their living environments are valued as social activities [43] (p. 277) that contribute to community and place-making. In this regard, we perceive the trial study and the participation in LHG machi-aruki as being an intangible result in and of itself. The future analysis of the data collected via the trial study aims at reporting on how participants assessed their experience, as well as reflecting on how the current proof-of-concept prototype of LHG could be improved. We have already managed to incorporate few of the comments and questions that we received from potential participants during the promotion of LHG and from participants in the first few days of the trial study in the current prototype, namely, enabling players to view in the app whether the bicycle was being used, and the addition of more game instructions. Future analysis results are expected to provide insights for the development of similar tools in this field. The future research steps to be undertaken are summarized as follows:

- Analysis of pre- and post-survey data, with a specific interest in the initial motivation of participants and its relationship with their engagement with the app, and their evaluation of the participation experience.
- Analysis of the qualitative data gathered mainly via online group discussions, in addition to field observations and written feedback from participants.
- Evaluation of LHG as a machi-aruki tool, looking at which characteristics were successful in achieving the desired tangible and non-tangible outcomes of machi-aruki, and which were less successful and need to be improved and bettered.

5. Conclusions

Machi-aruki is a shared practice which can change people's relationships with each other and their living environment. Through this article, we have sought to provide a rich and multi-faceted description of the design and development process of a proof-of-concept prototype for a gameful hybrid form of machi-aruki, called the Location Hunting Game (LHG). The design work presented here was a reflective process that combines theoretical concepts, practical goals, and design exploration. Describing LHG according to specifying key components and functionality can help other researchers develop similar technology in the context of urban planning applications.

The present work contributes to the discourse of the role of technology in participatory urban planning and consensus building. Alongside the potential of a wider audience reach, we argue that location-based interactions, online or offline, can transfer the knowledge of daily local realities, up in the urban planning pyramid, to inform urban decisions. We acknowledge the limitations of the current version of LHG in fully achieving machi-aruki's

goals; however, we believe that this tool is a promising proof of the concept of hybrid location-based participation in urban planning.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy reasons.

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