Design Principles for Content Creation in Location-Based Games

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Location-based games have been around since 2000 across various fields, including education, health, and entertainment. The main challenge facing such games is content generation. In contrast to normal games, content in location-based games is inherently dependent on location. The biggest challenge is the availability of the content globally. Other challenges include player engagement, enjoyable interactions with the real-world environment, safety, and customizability based on player performance and preference. While crowdsourcing has often been adopted as a tool for content creation, this approach requires quality control. Designing high-quality content requires detailed guidelines. In this paper, we introduce design principles for the creation of high-quality content that can survive for long periods of time. These principles are derived from ten years of experience running our in-house orienteering treasure-hunt game called *O-Mopsi*, which represents a case study in this paper. *O-Mopsi* allows players to visit pre-defined locations. The design principles are expected to be generalizable to other location-based games as well as to the creation of sightseeing tours more generally.

CCS Concepts: • **Human-centered computing** → **Interaction paradigms**;

Additional Key Words and Phrases: Content creation, quality evaluation, user-generated content (UGC), user-generated media (UGM), location-based game (LBG), orienteering, treasure hunting, *O-Mopsi*

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1 INTRODUCTION

Location-based games **(LBGs)** represent a relatively new game genre that leverages the positioning capabilities of modern smartphones. The genre's defining feature entails making players move around in the real world to perform actions in the game related to their physical location or interactions with other players. Augmented reality is often incorporated into LBGs like *Pokémon GO* to enhance the gameplay experience, though traditional treasure-hunt games like *Geocaching* generally focus purely on visiting pre-defined locations and interacting with whatever exists there. Creating content for LBGs represents the biggest challenge for global scaling, as content must be localized to every playing area. Even simple treasure-hunt games require a massive number of registered locations around the world. Even players of widely popular LBGs like *Pokémon GO* and *Ingress* often complain about a lack of locations. In fact, many LBGs do not even try to appeal to an international audience, limiting themselves to specific locations for the sake of practicality.

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Some attempts have been made to transfer content from one location to another for games that rely on storylines based on generic place types, such as cafés, shops, and libraries [1]. However, they still require large target databases. This is somewhat easier for games like *Pokémon Go*, the locations of which do not need to be specific **points of interest (POIs)**—any random location can work so long as it can be safely accessed by players. *Geocaching*, on the other hand, has succeeded by outsourcing content creation to its players through the creation of a strong community culture, which motivates players to create new caches and maintain the quality of existing ones [2]. A good game includes themes, (possibly) a storyline, a size, and a layout all of a high quality. If the game is to be played in one go, then the required walking distance should be reasonable, around 1–3 km. For games played across multiple sessions, the required walking distance may be larger. If finding locations is an essential part of the game, the game layout should involve some challenges. For example, *O-Mopsi* discretely includes the *open-loop traveling salesperson problem*, which provides a puzzle-like experience [3]. A target layout that creates a clear linear sequence may not present a sufficient challenge and, in turn, reduce player enjoyment; however, such a simple layout could be preferable for sightseeing tours.

This paper focuses on content-creation mechanisms in treasure-hunt games. We assume that the *game logic* (rules and goals of the game) is fixed but that the playground (game scenarios) varies and must be tailored to each location. If we have a large collection of target locations, the content-creation process is simplified to the selection of the best possible subset near the player's location. However, having a large collection of candidate locations is what most games are missing. The challenge is creating such a large collection anywhere in the world—and who creates it. We consider the following possibilities:

(1) Engage in manual creation by admins
(2) Encourage user-generated content via crowdsourcing
(3) Use external service providers
(4) Collect via web crawling

No matter which option we choose, the main challenge is quality control. Positive playing experiences require meaningful content that relates to its location. Quality is primarily a concern when material is automatically collected from the web or produced by external service providers whose content may be created for non-gaming purposes.

But what constitutes high quality? This question has been addressed by many researchers [2, 6, 10, 31, 42, 48, 56], as it is the most important individual factor in terms of attracting players. Several factors have already been identified. First, it is generally acknowledged that locations should be accessible and safe to visit—the basic requirement for any content. Pang et al. [4] reported that participants in their experiments understood how to create content but not how to make high-quality content. One of their recommendations is for visual clues to not be overly ambiguous to ensure that players can find the target. Lu et al. [5] observed that participants were very creative in content creation but lacked accuracy in the details. It is unlikely that we can simply teach creativity to content creators, but we can try to identify the most common mistakes and help people to avoid them.

Quality control can be managed in several ways. Player reviews are common, but there is simply too much content in LBGs to review, as playing activities are distributed across so many different locations. In fact, the rate of individual games receiving any review remains below 50% [6]. This shows a clear limitation of review-based quality control in LBGs.

But what actually constitutes *content* in treasure-hunt games? The main requirement is simple: have a place to visit. It can be any POI—a place with something interesting or notable that warrants a visit. We call such locations *targets*, as they do not need to be magnificent landmarks or tourist

Fig. 1. Example of typical targets in *O-Mopsi* game.

attractions; they just need to be easily identifiable. Examples of targets from *O-Mopsi* are shown in Figure 1.

In *O-Mopsi*, content is presented to players before they arrive at a POI, with the name of the place and its geotagged image already available. Other games may present players with tasks, such as taking pictures, answering questions, or learning about the story behind the target.

In this paper, we present design principles for content creation in location-based games. The principles have been developed based on our long-term experience creating and playing games. High-quality content is a key factor behind player immersion. We focus on individual targets consisting of three items: name, location, and media content. The five design principles are:

(1) Attractiveness
(2) Accessibility
(3) Location clarity
(4) Identifiability
(5) Lifetime of a target

These design principles may be viewed as quality criteria for the targets in the game. They aim to support admins in content creation, but they can also be used in the creation of crowdsourcing guidelines, which may facilitate a semi-automated approach through which content is generated automatically but crowdsourcing is used for quality control. Some of the guidelines may even be suitable for automatic content validation.

The remainder of this paper is organized as follows. In Section 2, we review existing location-based games. In Section 3, we discuss content creation and quality control. In Section 4, we briefly assess *O-Mopsi*, a mobile orienteering game. In Section 5, we introduce the design principles using *O-Mopsi* as a case study. In Section 6, we discuss validation with survey results among players. Finally, in Section 7, we draw some conclusions and outline potential avenues for future work.

2 LOCATION-BASED GAMES

This section reviews the various types of location-based games with a particular focus on educational games and motivational aspects.

Geo-caching is the oldest location-based game that is still popular globally. Players seek hidden containers called *caches*, each of which contains a logbook and small items for trading. Other treasure-hunt games have been developed since *Geo-caching*, but it remains one of the few that have survived up to today.

Pokémon GO was a cultural sensation when it launched in 2016, garnering massive commercial success. It is widely credited for popularizing both location-based games and augmented reality. The gameplay revolves around wandering around the real-world environment to find and catch wild *pokémon* creatures. Using augmented reality, players see the pokémon in the real world and toss pokéballs at them to catch them.

Harry Potter: Wizards Unite is similar to *Pokémon GO*, but players search for Foundables—magical items from the Harry Potter universe—instead of pokémon. *Ingress Prime* requires players to

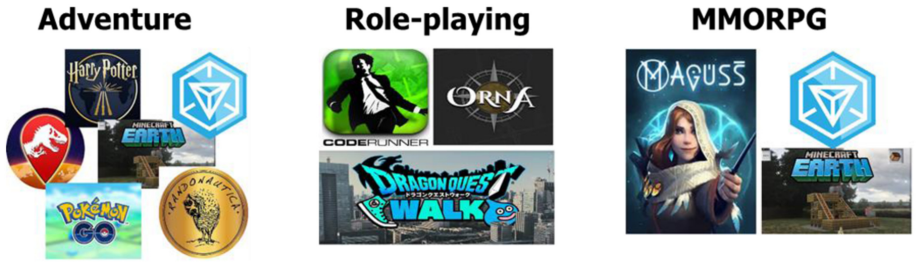


Fig. 2. Typical genres of location-based games.

interact with target locations, called *portals*, which are typically public art installations, such as statues, monuments, historic buildings, and outdoor murals. *Minecraft Earth* was centered around exploring, gathering resources, crafting, and building structures. In *Landlord*, the player starts with a generous loan of in-game currency that they must invest to become a real estate mogul [7, 8].

2.1 LBG Categories

We consider there to be five LBG categories in terms of gameplay motifs: *fantasy and role-playing, motivational, learning, adventure/action*, and *treasure hunt*. These categories are the result of our synthesis of all possible categories used in the LBG games discussed in this paper as follows. We first took the most relevant listed category (or tag) of each game, as found in the literature or in the Google Play store, and then selected the five most descriptive.

Fantasy and role-playing: LBGs that involve fantasy and role-playing elements are very popular. They combine augmented reality with real-world navigation. *Randonautica* is similar to *Geo-Caching*, but it features mystical elements. In *Ingress* [9], reality is augmented by a story of a powerful alien energy and two factions fighting for control over the game map.

Maguss is a **massively multiplayer online role-playing game (MMORPG)** in which players are wizards who cast spells, battle magical creatures, and duel other players for glory and treasure. In *Orna: The GPS RPG*, players explore a fantasy world, defeat monsters, upgrade equipment, and fight against one another. *Ghostbusters World* requires players to clear ghosts from the world, discover hidden locations, and level up their powers as they run around their haunted neighborhood. *Dragon Quest Walk* is a role-playing game available only in Japan. Its gameplay is centered around interacting with various monsters and characters from the Dragon Quest series. Players battle monsters to obtain items and strengthen their character in order to advance through various quests.

Laato et al. [10] identified six sub-genres of location-based games: (1) treasure-hunt games; (2) MMORPG; (3) spatially aware games; (4) geolocation games; (5) movement-dependent games; and (6) miscellaneous games. This paper focuses on the first sub-genre: treasure-hunt games. The genre categorizations used by the Google Play store are shown in Figure 2. Treasure-hunt games belong to the adventure genre.

Motivational: Games are typically created just for fun but many have begun to be motivated by their health effects [11]. *Ristinummi 2.0* is a game similar to *Geo-Caching* that features narrative elements [12] with the aim of encouraging elderly people to socialize and be physically active by exploring local places. Playing *Pokémon GO* has also been reported to help players to overcome social barriers, reduce anxiety, lose weight, and connect with others who share their passions. Kasapakis and Gavalas [13] state that the most preferred characteristics of *Ingress*, according to the players, were being outdoors (1st), exploring the environment (2nd), and socializing (3rd).

Learning: Some games aim to be useful and informative. *City Explorer* [4] is a mobile game that allows people to explore areas and learn information about the local community. It encourages

players to share content related to their trips. Experimental results showed that people were less interested in face-to-face interactions and that the need for personal space was more important than interaction with new communities. Its players were interested in the *detour challenges* only when they had spare time (e.g., they missed a bus and needed to kill time). *TaleBlazer* is one of the most cited platforms for creating and playing location-based augmented-reality games in learning contexts [57].

Adventure/Action games: Many games are centered around action. In *GeoSnake* [6], players must visit several places in a way that prevents their travel path from crossing itself. In *Street Art Gangs* [14], teams compete to dominate predefined locations around downtown Oulu, Finland by physically tagging them. The game can be played both in the real world and in a completely virtual manner. Players prefer to play the game on real city streets, while the added value of the virtual game remains marginal. The size of the game in terms of both the area and number of taggable locations has major impacts on gameplay. A larger game area and a larger set of taggable locations appear to mask many of the problems that players of location-based games have with location uncertainty.

Treasure-hunt: In treasure-hunt games, people simply need to find locations, which we refer to as *targets*. In *Big Game Huntr* [15], players need to find targets based on clues and either take photographs of the specified objects or complete some tasks to gain points. Game developers must then accept the validity of the photographs. The targets can be landmarks, decorations (e.g., Christmas lights), or actions (e.g., the conga). In *Barbarossa* [16], the player acts as a knight of St. John trying to liberate a conquered city by eliminating his enemies. The targets include quests that align with the history of *Mytilene. Tidy City* [17] used riddles with a task to determine the real-world locations that each riddle describes and verify it by visiting the location. Players are rewarded with points for solving riddles, and these solutions become descriptors for new locations.

2.2 Stories and Educational Games

Many games involve a storyline or an overall mission. *Zombies, Run!* [62] is an immersive running game in which players take on the role of a character called *Runner 5* in a series of missions that require them to run while listening to various audio narrations to uncover the story. *CodeRunner* [63] is a spy game in which the player takes on the role of an undercover agent and completes simulated espionage missions. It uses real locations as mission targets that players must visit to play through the story. *Jurassic World Alive* [64] requires players to explore the real world to collect dinosaur DNA. The collected DNA is used to create a squad of dinosaurs that players can use to battle against one another in real-time matches.

Games involving storylines are often called *one-off* games because, once played, repeating the same game is largely unappealing. The stories can be informative, educational, or fictional. *Environmental Detectives* [65] was the first location-based educational game, created by **Massachusetts Institute of Technology (MIT)** and aimed at high school and university students. The gameplay requires players to uncover the source of a toxin spill on their campus.

Educational games can be made on any topic. For example, *Savannah* [18] teaches players to understand the behavior of lions through personal experience, helping them to understand the daily key decisions that lions make to survive in the wild. Many subjects are not easy to transform into a location-based game—but attempts have still been made. For example, in [19], players act as consultants who interview virtual characters around their campus to receive information about business practices. However, the character locations have nothing to do with the subject matter; it simply serves to move business education out of the classroom.

Evidence suggests that students can make significant learning gains through game-based learning relative to classroom settings [20]. However, just being location-aware and moving teaching

Fig. 3. Examples of potential educational games created using a simple application like *O-Mopsi*. Biology is likely the most straightforward topic in terms of practical implementation.

beyond the classroom are not enough to improve performance; designing high-quality content is important [21]. Educational games can be easily created for biology by marking natural objects with brief descriptions, such as the names of different tree types. Other particularly suitable subjects for educational games include local history (see Figure 3).

Education on local history has been the driving motivation behind several location-based games. *O'Munaciedd* [22] was designed for children. It combines having fun with learning at historical sites in the city of Matera. *The Heraklion Fortification Gates* [23] is a game that enables players to study the history of the Venetian walls of the city of Heraklion (Crete). When a player reaches a gate, the game offers information about the history of that gate. Notably, such games must have interesting design and content to attract and maintain players' interest. Oftentimes, specialists must aid in the development process to create the content and design the learning path for the game.

Frequency 1550 [24] was developed to help first-year students in secondary education to acquire historical knowledge about medieval Amsterdam. Evidence shows that players gained significantly more knowledge than people who received standard history lessons. *Premierløytnant Bielke* [25] teaches the history of Berged during the Napoleonic Wars (1803–1815). In *Hidden Lion* [26], players wander around the city of Anping, Taiwan to find the sword lions. Once they find one, players are prompted to learn the background story of that particular sword lion.

Museums constitute another suitable context for location-based games. *Museum Scrabble* [27] aims to engage students, making them focus on specific information about a set of key exhibits and then use their imagination to search for relevant exhibits in the museum. *LieksaMyst* [28] is a story-based role-playing game, aimed at motivating children and young adults. The gameplay takes the player back in time to meet fictional characters who are said to have once lived in the old buildings of Pielinen Museum. *Mystery at the Museum* [29] is an interactive mystery game designed to engage visitors more broadly across various museum exhibits and promote collaboration between visitors.

Overall, developing narratives and educational games requires more effort and knowledge about means of creating pedagogical content. For this reason, many educational games make people wander around without utilizing their surroundings. With this approach, content creation does not differ much from the creation of traditional educational content. This reduces public interest in the game, as context-related quests are generally regarded as higher-quality [30].

3 CONTENT CREATION

In this section, we provide a review of the literature on existing solutions for content creation. Open questions are who creates the content, and how do they create it? How can we maintain effective quality control? What exactly is the content in location-based games? We also study how widely the proposed design principles have been used in the literature.

3.1 User-Generated Content

Oppermann and Slussareff [31] argued that creation of location-based games requires different skills: programming, game design, and content creation. They also noted that content is typically assumed to be created by game developers. However, this is not always the case [31]. Ideally, games would be able to be played anywhere, but creating content for every city across the world would require a massive amount of effort. As a result, even the most popular games are not available worldwide [32].

Pokémon GO and *Ingress* are two widely spread games. They both share a community-built database of locations around the world, but users still complain about a lack of locations in many areas. One reason why *Geo-Caching* has remained popular is that it has succeeded in the realm of content creation. According to Neustaedeter et al. [2], the ability of players to create their own content and monitor the content of others has greatly contributed to the success of the game. They listed three game categories based on who creates the content:

(1) Admins
(2) Players
(3) Computer

Some examples of games for which admins create content are *Ambient Wood, Savannah, Treasure, Uncle Roy,* and *Anywhere. EyeSpy* and *Geo-Caching* are games that rely on players. Games for which content is automatically generated during gameplay include *Feeding Yoshi, CYSMN?, Randonautica*, and *Blowtooth*. Games like *O-Mopsi, Ingress Prime,* and *Pokémon GO* allow both admins and players to create content (see Table 1).

Due to the challenges of content creation, most games are limited to specific locations and heavily depend on organized support teams to maintain both new content and content quality. Kasapakis and Gavalas [6] argued that manual content creation is not incompatible with portability, concluding that user-generated content constitutes the only practical option. Their experiments with *Barbarossa* confirmed that user-generated content can enhance gameplay quality. However, while players appreciated the game's concept, they were critical of its user-generated content.

Allowing non-experts to generate content for games has two major challenges:

- How can we motivate users to create content?
- How can we guarantee the quality of user-generated content?

Geo-Caching's long history has created a strong culture among the player base. It helps to ensure that players are highly motivated to create content as well as monitor the quality of the caches. One example of this type of playing culture is that there is no written rule saying "*report muggle activity.*" However, players have learned to do it anyway, as it is important that muggles (non-players) do not see the caches [2].

Newer games may not have such influential cultures among the player base. As a result, explicit tools are necessary to encourage both content creation and quality control. Casey et al. [33] argued that a meaningful reward system is necessary to motivate players to create content. Massung et al. [34] compared three mobile crowdsourcing alternatives: first, financial rewards; second, virtual

Table 1. Content-Creation Sources of Different Games

Game:	Genre	Content Creation:		
		Administrators	Players	Computers
Ambient Wood [2]	Learning	✓		
Savannah [18]	Learning	✓		
Treasure [2]	Treasure-Hunt	✓		
Uncle Roy [2]	Adventure/Action	✓		
Anywhere [2]	Learning	✓		
EyeSpy [35]	Crowdsourcing/Motivational		✓	
Geo-Caching [2]	Treasure-Hunt		✓	
O-Mopsi [3]	Treasure-Hunt	✓	✓	
Feeding Yoshi [2]	Adventure/Action			✓
CYSMN? [2]	Adventure/Action			✓
Blowtooth [2]	Action			✓
Randonautica [66]	Adventure/Action			✓
Ingress Prime [8]	Adventure/Action	✓	✓	
Pokémon GO [58]	Adventure/Action	✓	✓	
Harry Potter: Wizards Unite [67]	Adventure/Action	✓		
Jurassic World Alive [64]	Adventure/Action			✓
Walking Dead: Our World [68]	Action			✓
Draconious Go [68]	Adventure/Action			✓
Niantic Wayfarer [61]	Maps and navigation		✓	

rewards; third, no rewards. The application with financial rewards generated the most content, while the one without any rewards generated the least. However, there was no notable difference in quality.

In *EyeSpy* [35] players share pictures of locations with others, who then try to determine where the pictures were taken. Goh et al. [36] created two different applications for content collection: a competitive game and a non-gamified application. They found that the game generated twice as much content as the non-gamified application. This suggests that there can be two different types of games: one for the purpose of content collection and another that depends on pre-existing content. Why make collection burdensome when it can be fun?

Giannakos and Jaccheri [37] found that ease and usefulness are the most important factors that motivate teenage students to participate in creative game development. Ukpabi and Karjaluoto [38] listed several factors that affect user-generated content creation, including *usefulness*, ease of use, and attitude. Similar results were reported by Giannakos and Jaccheri [39] who found out that ease and usefulness were the most important contributors—even more important than enjoyment and satisfaction.

Harjarnis et al. [1] introduced the concept of *location translation*, which aims to shift a game's applicability to a completely different location. The concept was created for alternate-reality games with a story represented as a dependency graph in which each node corresponds to a story event, and the (directed) links impose constraints on the order in which events may be visited. Given a set of event locations, txhe idea is to find another set of locations that (1) maximizes the similarity of their content and (2) minimizes the physical distance between adjacent locations. For example, if the location is at a shop in the original game, it would be preferable for it to be at a shop in the new game as well. This pursuit of translation effectively becomes an optimization problem called *minimum balancing difference* [32]. While this approach is towards automating the

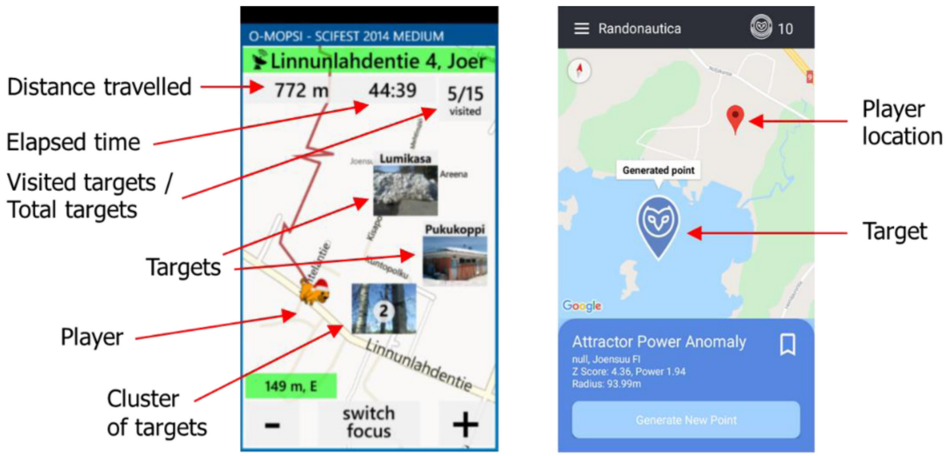


Fig. 4. *O-Mopsi* (left) interface showing targets on a map. Each target comprises three elements: name, location, and picture. The number on one image indicates that it is a cluster of two targets, only one of which is shown. To see both targets, users must zoom in on the map. Randonautica (right) interface shows an example of a generated target for a player to explore.

content-creation process, it focuses on the layout problem; the candidate locations must still be found some other way.

3.2 Content in Treasure-hunt Games

What content do we need in treasure-hunt games? The main rule is that content should be coupled with locations that correspond to publicly available POIs, such as well-known landmarks. In orienteering games like *O-Mopsi*, any identifiable target can work, as the main challenge is finding the targets in an efficient manner (or simply collecting all of the targets).

In addition to location, targets consist of media items (usually photos) and name. Questions and storylines can be attached to the targets, especially in educational games. *Tidy City* [17] displays riddles on a map, and players must determine which real-world location each riddle describes and verify it by physically visiting that location. However, in games like *Randonautica*, targets contain no media items; players need to explore interesting objects based purely on their own interest. Figure 4 presents examples of *O-Mopsi* and *Randonautica* showcasing nearby targets.

FitzGerald [40] analyzed user-generated content and found that 92% of games contained photos. Short text descriptions were present in 88% of games, while specific information about object shape, color, or size was present in 68% of games. Augmented reality has also been utilized. Cochrane [41] provided a conceptual framework for implementing student-generated mobile virtual reality within a design-based research methodology across three disciplines: paramedicine, journalism, and new media production. One downside is that if a game's design is highly visual, it may lead users to focus on the screen space and forget about their environment [31], leading to safety issues.

3.3 Quality of the Content

The main challenge of user-generated content is guaranteeing a certain level of quality. Matyas et al. [42] argued that data crowdsourced from non-expert users is rarely of high quality. While admins are experienced in their game and its content-creation method, even a good player may not have sufficient experience to create interesting content and avoid typical pitfalls (see Figure 5).

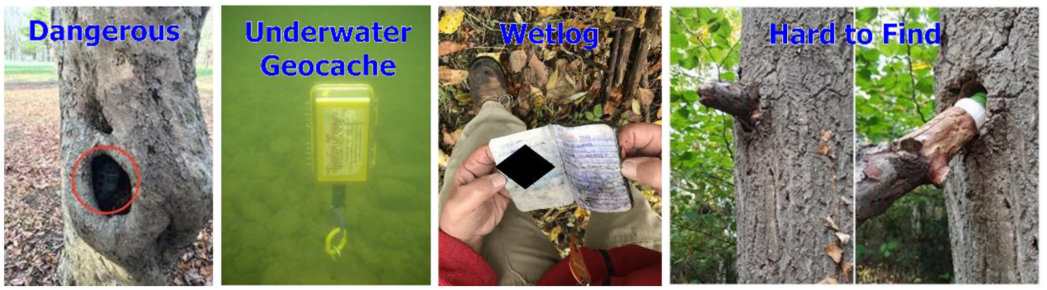


Fig. 5. Examples of problems that lower content quality.

Most of the earliest systems used either use review-based quality-control mechanisms or had no quality control at all. According to Matyas et al. [6], the standard review rate lies between approximately 30% and 40% of content, meaning that more than half of data is of an unknown quality. This clearly restricts the usefulness of review-based quality control.

But how do we define "high-quality content?" Neustaedter and Judge [43] listed the following problems regarding *Treasure Hunt*, a game similar to *Geo-Caching*: visibility, accessibility, layout, and ease of identification. Visibility problems meant that the game struggled to strike a balance between treasure being hidden and the avoidance of excessive ambiguity. Accessibility problems refer to locations that cannot be entered without trespassing. Layout problems refer to treasures being too far apart. Finally, ease-of-identification issues refer to treasures being too difficult to find or even missing. These problems caused countless issues with users, especially new users. Participants understood how to create content—but not high-quality content. Their conclusion was that content must be reviewed for quality. The main issue they ran into was that reviewing content quality on specific targets is difficult without actually visiting those targets. Ultimately, they concluded that user-generated content should be permitted only once the game has established a certain level of maturity.

Neustaedter et al. [2] made similar observations about *Geo-Caching*. Rather than visiting the caches themselves, most cache creators relied on logs that people wrote about their cache experiences to help maintain them. This approach corresponds to review-based quality monitoring. In other words, cache creators generally relied on players who visit their caches to log their experiences online and report any problems that they encounter. This may only work in *Geo-Caching* due to the pre-existing strong culture among its player base. More generally, they recommended minimizing monitoring activities and offering in-game rewards engaging reviews.

UrbanMatch [44] tasks players with finding the most representative photos related to locations in Milan, Italy. Players are shown photos from a trusted source, and they need to link these photos to a selection of other photos from non-trusted sources. The more that players couple a distrusted photo with a trusted one, the stronger the distrusted photo becomes in terms of qualifying to represent the location. Overall, 99.4% of links between a trusted source and a distrusted source were found to be correct. However, this approach suffers from the cold-start problem: what if there are no trusted photos of a location to begin with?

Lu and Arikawa [5] allowed players to create their own maps for the game. They found that the maps created by their players were very impressive in terms of creativity and theming but lacked accuracy. Once again, this demonstrates the need for quality control over user-generated content.

Massung et al. [34] used a few simple rules to improve content quality. First, target information was only accepted once validated by two independent users. Second, participants were able to create content only within 200 yards of their current location and able to rate others' content just once per day. As a result of these rules, the quality of the data became very high.

The need for quality control was also observed in *CityExplorer*, in which users were found to value factual information rather than opinion-based information [4]. This follows the general trend of people reducing their use of social media and returning to more established and trusted media outlets (see Andone et al. [58], Budak et al. [59], and Zannettou et al. [60]). Erlacher et al. [45] discussed a web-based portal for collecting and sharing locations, observing that quality strongly depends on users' local spatial knowledge and community willingness to verify the content that stems from that knowledge.

3.4 Principles for Content Creation

Regardless of who generates the content, quality control represents a critical challenge that calls for the formalization of certain principles. Currently, many games lack guidance with regard to how media content should be generated, resulting in significant variation in quality. FitzGerald [40] presented guidelines for content creation in educational games that sought to capture pedagogical aspects, human-computer interactions, and environmental aesthetics with a focus on six aspects: landscape domain, type of communication, use of language/media related to the landscape, knowledge level of content, contextual aspects, and types of interaction.

Schito et al. [46] provided a six-step didactic planning framework for the integration of location-based games into practical teaching: (1) set the scope; (2) select a learning paradigm; (3) select places; (4) select a class structure; (5) develop learning material; and (6) seamlessly embed in the syllabus. They expect games in this learning paradigm to be mainly repetitive; therefore, such games should mainly reuse existing teaching (pedagogical), allow offline capabilities (technical), lean toward a constructive approach that entails group work, and be introduced in an interesting manner, making participants eager to achieve the goals.

Heljakka and Ihamäki [47] suggested guidelines regarding what to consider when designing urban game adventures with potential learning goals in mind. The guidelines were designed based on a story-telling game called *Sigrid Secrets* in the city of Pori on the west coast of Finland. They developed three main guidelines: (1) design the goal and game mechanics to be easily understood with a game length that matches player expectations without any background information; (2) cooperate with local authorities to ensure that identified physical installations will stay intact; and (3) design game characters to be approachable and child-friendly to ensure that players are not scared off by anything creepy. They consider mainly physical and technical pitfalls, such as lack of WiFi, weather conditions, and how to consider needs for child players.

Kultima [48] defined four criteria: acceptability, accessibility, simplicity, and flexibility. Acceptability means that the game's processes are favored by a significant number of people. Three design principles were crafted to fulfill this criterion: (1) game content matches the norms of the player's social context; (2) game avoids offensive topics like violence, sexuality, and explicit language; and (3) game uses mechanics such as building, collecting, nurturing, exploration, and collaboration instead of destruction, killing, fighting, and survival. Among the other values, accessibility refers to cognitive accessibility rather than physical accessibility at the game site. For example, the stories presented at the locations should relate to the local social context. Simplicity calls, for example, for easy-to-use interfaces. Finally, flexibility requires a game to be adaptable to various situations through the facilitation of user-generated content and functional adjustments.

Matyas et al. [6] introduced design patterns for users to consider during data collection. These include two rules: (1) choose a GPS coordinate that certainly identifies the place; and (2) choose a GPS coordinate that you think other players also chose. The idea of the second rule is to trick users into providing a more accurate location of the place.

Söbke et al. [49] proposed a pervasive game design framework using *Ingress* as a case study. They found that the three main benefits of *Ingress*'s gameplay are socializing, outdoor activities,

and exploring the environment. While not firm guidelines for content creation, keeping these benefits in mind may help developers create more tangible design principles.

Oppermann and Slussareff [31] offered ten guidelines including safety and accessibility. Natural boundaries like rivers and hills, and lack of GPS signals are factors that can limit accessibility. Smartphones could also be limited in certain locations, such as saunas and cemeteries. They also noted that location-based experiences must not be authored without visiting the location in person. Even stories about the locations are best created when physically present at the location, even if the content creator is a tour guide or a teacher with knowledge of the area. They also mentioned weather limitations.

Laato et al. [10] provided three factors to measure the quality of a target location: (1) its connection to real-world places, (2) its uniqueness and metadata, and (3) its placement. Uniqueness and metadata refer to whether it has a unique name and image associated with it. Placement refers to safety and accessibility issues. These three factors were used to compare manually created point-of-interest databases against databases automatically created through **open-street maps (OSM)**.

Polson et al. [51] proposed three conceptual layers for game localization, noting the following three challenges:

(1) How can (arbitrary) games be localized?
(2) How can location-based games be re-localized?
(3) How can environments be gamified?

These and most other existing guidelines are too general and lack detailed instructions. Alternatively, they focus more on the game rules than the content. Many guidelines are available for educational games and storyline creation, but less attention has been paid to how to create media content for simpler treasure-hunt games. The next section presents a case study of *O-Mopsi*, our orienteering game, to propose design principles for creating high-quality content with a focus on media content. Finally, no matter what guidelines are provided for content creation, one must keep in mind that the most important aspect is still a simple and easy-to-use user interface, without which there is no hope for success.

Table 2 summarizes the proposed design principles in terms of their prominence in the existing literature, revealing that only accessibility has been widely considered by other researchers. The others—location clarity [2], identifiability [6], and lifetime [42]—have been covered only by a few works. Attractiveness has not been explicitly mentioned by any previous study. In summary, the existing quality criteria are mostly relevant but, overall, insufficient.

The proposed principles closely resemble the quality criteria used in a community mapping program called *Niantic Wayfarer* [61]: (1) a great place for exploration, exercise, or socialization (attractiveness); (2) permanent and identifiable place or object (identifiability, lifetime); (3) safe and publicly accessible (accessibility); and (4) accurate information (location clarity).

4 O-Mopsi

O-Mopsi (http://cs.uef.fi/O-Mopsi) is an orienteering game played outdoors by finding real-world targets using a smartphone [3]. The game is similar to classical orienteering with a few key differences (see Figure 6). First, navigation is easier than in classical orienteering, which usually takes place in a forest that lacks houses, roads, and visible landmarks. *O-Mopsi* is generally played in cities and parks, making it easier to play. Second, classical orienteering entails self-positioning through the use of a compass and a paper map; in *O-Mopsi*, a player's current location is always visible on the smartphone, making navigation easier.

What makes *O-Mopsi* challenging is that the order of the targets is not fixed. Players must optimize their tour without any guidance from the system (see Figure 7). This ordeal corresponds

Table 2. Proposed Design Principles Covered in the Literature

	Publication Year	Design principles				
		Attractiveness	Accessibility	Location Clarity	Identifiability	Lifetime
Matyas et al. [42]	2008	-	-	-	-	✓
Kultima [48]	2009	-	✓	-	-	-
Polson et al. [51]	2010	-	-	-	-	-
Matyas et al. [6]	2011	-	-	-	✓	-
Celino et al. [44]	2012	-	-	-	-	-
Erlacher et al. [45]	2012	-	-	-	-	-
Neustaedter et al. [2]	2013	-	✓	✓	-	-
Massung et al. [34]	2013	-	-	-	-	-
Lu and Arikawa [5]	2015	-	-	-	-	-
Schito et al. [46]	2015	-	-	-	-	-
Oppermann and Slussareff [31]	2016	-	✓	-	-	-
Söbke et al. [49]	2017	-		-	-	-
Heljakka and Ihamäki [47]	2018	-	-	-	-	-
Laato et al. [10]	2019	-	✓	-	-	-
Arango-López et al. [56]	2021	-	✓	-	-	-

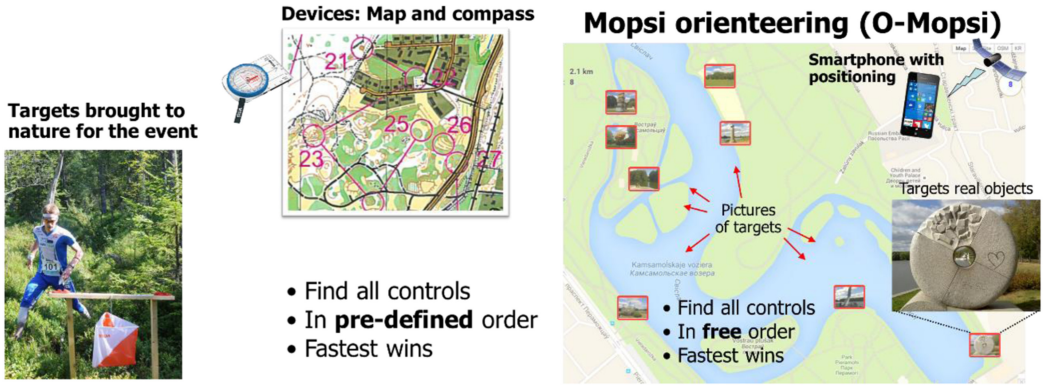


Fig. 6. Classical orienteering (left) versus location-based orienteering in *O-Mopsi* (right).

to the traveling salesperson problem, which is well-known as a computationally difficult problem. This means that even computers struggle to solve large-scale problems of this nature within a reasonable amount of time. However, small-scale problems featuring 10–20 targets serve as good puzzles for humans, providing a challenge while still being enjoyable [52].

A *target* in *O-Mopsi* comprises a name, location, and photo. Finding a target is mentally rewarding and constitutes the main motivation to play the game [3]. Targets are automatically presented on the map before the user starts moving. This helps the player to get a sense of their surroundings and their objectives. The positive aspect of this game is that it encourages users to exercise and go outdoors, providing them with both physical and mental health benefits—far more than are provided by most videogames. To complete a game, the player must walk anywhere from 1 km to several kilometers.

O-Mopsi was first launched in 2011 at the Science Festival in Joensuu (SciFest), an event aimed at familiarizing school kids with science. Those who played the game loved it. The feedback from

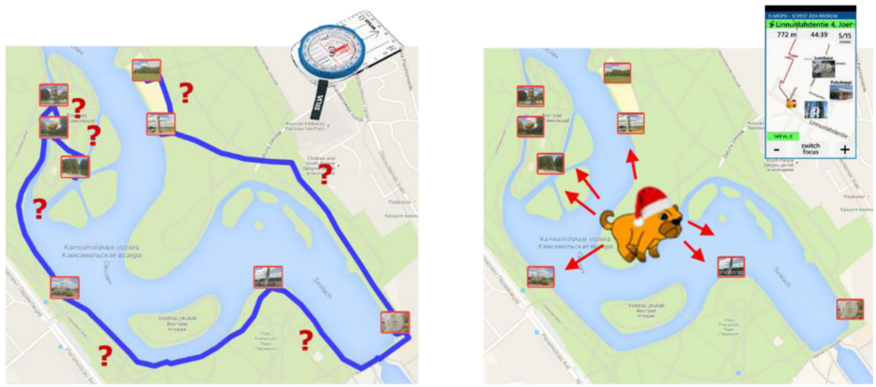


Fig. 7. Challenges in classical orienteering (left) and *O-Mopsi* (right).

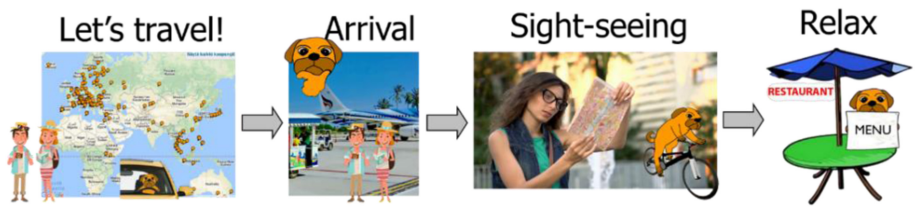


Fig. 8. Trip cycle of a traveler and how to get them involved in a sightseeing game.

users at that festival made it clear that the game has the potential to become popular [3]. Three playing modes have been considered:

- Competitive gaming
- Educational
- Sightseeing

O-Mopsi can also be used for sightseeing tours. When people travel, they may enjoy their thematic tours being framed as a game rather than a standard guided tour in a predefined order. Additionally, with its easy-to-use interface for content creation, people can create their own tours for others to play. Games can essentially be thematic tours across a city, attractions in a park, or favorite places in the game creator's hometown, enabling countless possibilities. Sightseeing tours can be made easier by recommending a specific order with pre-defined start and end points while still allowing for user-directed trip orders.

Figure 8 shows a potential traveler scenario. After reading travel stories and seeing photos of others, the traveler decides to go on a trip. After booking the trip, she arrives at the destination without a detailed plan for what to see. The traveler then opens *O-Mopsi* to look at recommended tours and destinations. After a few hours of sightseeing, she ends the tour at a café (which may or may not be a part of the tour) to relax. After the trip, she can share the pictures she took on the tour through *O-Mopsi* to improve other users' experiences.

We recommend a distance of 100–400 m between targets. If targets are too close together, finding the next one can be too easy, reducing the challenge and, in turn, the enjoyment. If targets are too far apart, users can get bored, especially if there are no navigational challenges along the route (see Figure 9). Game mechanics must include challenges [53]. A good game has a challenging layout to

Fig. 9. General principles for designing *O-Mopsi* games; a campus game used in Joensuu Science Festival (SciFest) in 2014 (left); a sightseeing tour around Marina Bay in Singapore (right).

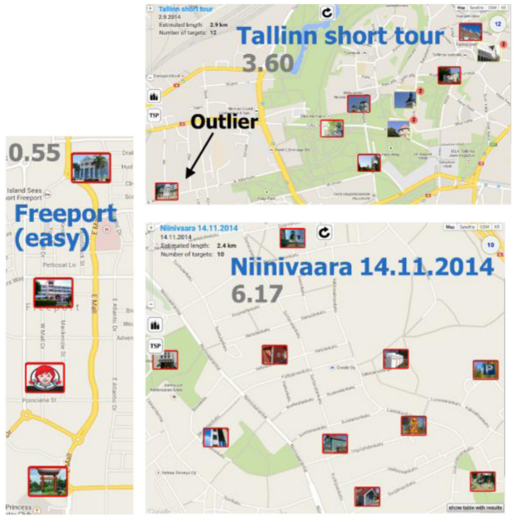


Fig. 10. Three examples of tours with layouts that vary in difficulty. The grey numbers indicate difficulty as estimated by the *greedy gap* in [52], with higher values indicating greater challenges in terms of solving the optimal visit order.

provide users with a non-trivial puzzle to find the best visit order. Figure 10 shows three examples. *Freeport (easy)* is trivial due to the linear structure of the targets. *Tallinn short tour* is generally well designed but has one notable outlier far away from the others. Players may be frustrated after visiting all of the central targets only to find out that there is one more target far away. *Niinivaara 14.11.2014* is the most balanced layout, as the targets are randomly distributed but equidistant to one another, making it a good puzzle. Can you find the optimal tour route? The solution is shown at the end of this paper.

Based on the experiments at SciFest [3], players strongly prefer shorter tours. Thus, the number of targets should be relatively small, preferably from six to ten. Another potential way to improve user experiences is to make tours cyclical, enabling players to start at any point in a tour and ultimately end the tour in that same spot or somewhere nearby.

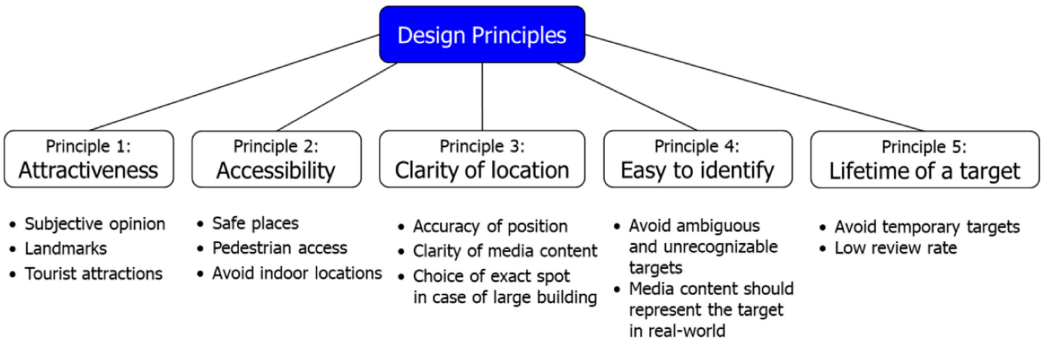


Fig. 11. Five design principles for content creation in location-based games.

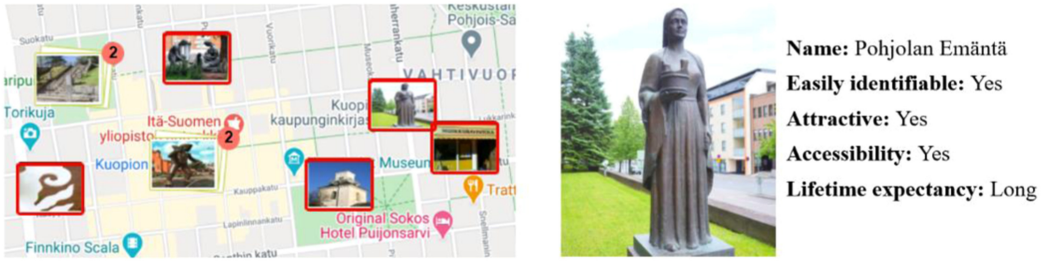


Fig. 12. Targets in O-Mopsi (left) and one target and its components (right).

5 DESIGN PRINCIPLES FOR CONTENT CREATION

In this section, we introduce our design principles (summarized in Figure 11 alongside potential guidelines). They are intended for anyone involved in creating content for location-based games. The principles are based on our long-term experience running *O-Mopsi*, which launched in 2011 at SciFest without any formal guidelines. At the time, we received some complaints about targets being unclear, unattractive, or difficult to reach. The inaccuracy of GPS signals caused unpleasant gaming experiences in some cases. As more games were created in the years that followed, attention was increasingly paid to content quality, and design principles were slowly born—but never formalized until now.

A target comprises three components: name, location, and media content (see Figure 12). Location is the most essential, as it defines where the player must go. In Pokémon GO, any accessible location can be used so long as it is safe for pedestrians. However, the location should feature an identifiable object for players to find. The name should be short (preferably just one or two words) and capture the essence of the target. Short names are easy to remember and fit better on smartphone screens. Names of commercial sites are generally acceptable, as they typically feature short and catchy terms (e.g., Gaude, Rosso, Starbucks). Statues and historical places often have long names (e.g., Terrace of the Lions, Spring Temple Buddha, Wat Phra Si Sanphet). If the material comes from a database designed for another purpose, renaming targets may be necessary (see Figure 13 for a few examples).

Targets in games like *See It* [54] and *TidyCity* [17] can survive without any name because the goal in those games is to solve puzzles like "*find this place*" based on some riddle. Media content itself is easy to produce, but there are many pitfalls that only an experienced content creator can detect. Anyone can take pictures, but few can take aesthetically satisfying pictures. Similarly, only an application expert knows all criteria that need to be fulfilled. Note that short video clips can also

Fig. 13. Names from a user-collected database in need of revisions. They should be short and specific to something tangible that players can easily identify at the location.

Fig. 14. Examples of good targets. They do not need to be huge; they can also be small but clearly identifiable objects that have aesthetic value, represent something essential about the location, or feature information to guide onlookers and visitors.

be used instead of still pictures [54]. Media content should be appropriate for its game's purpose, application area, and target group and include only necessary information [55]. While the layout of the game is also important, this paper is focused on the quality of individual targets rather than the overall entity that they form.

Next, we discuss the five design principles in detail, using real targets from the *O-Mopsi* target database as examples to demonstrate the principles. These targets have been created both by admins and by crowdsourcing.

5.1 Attractiveness

The quality of a target depends mostly on the motivations of the tour and the preferences of the player. For a sightseeing tour, statues and landmarks are obvious targets. However, thematic tours may include lesser-known locations as targets. Figure 14 shows a few examples of typical targets suitable for both gaming and sightseeing.

The statue of Johan Strauss in Vienna represents a prominent person in the city's history. The reading girl statue in Công Viên Thống Nhất park in Hanoi represents the learning culture in Vietnam. The sea museum in Vaasa represents the city's extensive maritime history. Sometimes, however, the content itself is not incredibly important. For example, if a tour is more oriented toward puzzle-solving or wandering in nature, targets can be any recognizable objects, even including something like a sign.

Fig. 15. Accessibility can be limited by forbidden areas (Flamingos), seasonal blockades (Hut), and periodic events that limit free access (Horse racetrack).

A lot of games have been built around a specific location and, therefore, cannot be easily translated to other places, as they rely on a particular set of stories and knowledge. Examples of such games are *Hidden Lion* in Anping, Taiwan [26], *See It* in Vancouce, Canada [54], *Museum Scrabble* in Zakynthos, Greece [27], and *O-Munaciedd* in Matera, Italy [22]. Creating a new tour in *O-Mopsi* requires only limited local knowledge. However, as highlighted in [38], location experts are likely to provide better content than non-locals. This is important, as people have been shown to favor factual information [4].

However, knowledge of the local area is not enough. We expect that a skillful and experienced content creator would make a better tour around a place they've visited just once than a local expert who lacks design skills and creativity. Having clear guidelines can help in this regard.

5.2 Accessibility

Accessibility is important, as it involves safety and accessibility of locations. Targets should not be placed on private property, dangerous areas (e.g., highways), or pedestrian paths where intensive smartphone usage would be a safety risk. The outdoor accessibility is not always obvious, as shown by the examples in Figure 15. Otherwise, there are no major limitations on what places can be considered.

Indoor targets should also be avoided, as current GPS-enabled positioning technology often becomes unreliable indoors. Figure 16 presents a few possible exceptions to this rule. The Tradeplay statue is in a lobby close to the main entrance, the idea being that players would register the target upon seeing it. In practice, however, the target is caught before the lobby door even opens or it is not caught at all due to GPS failure. The same applies to the Starbucks Christmas decorations in the lobby of Fusionopolis in Singapore. While it makes for an attractive target that is visible through the glass doors, it is a bit too far indoors to be reachable using GPS. The picture of the Shop target is taken from the entrance of the shop, which doesn't run into any GPS issues—however, that effectively constitutes an outdoor target at that point.

While Kowloon Park in Hong Kong is open to the public, the area featuring flamingos is like a zoo and prevented from pedestrian access by wrench. Sometimes, a lack of access is seasonal, such as the snow blockade in front of the Hut. Sometimes, the place is seemingly open but holds weekly events that hinder free access (Horse track race). There are also places like Tallinn Old town having inner yards that are accessible during the daytime but closed in the evenings, which should also be considered.

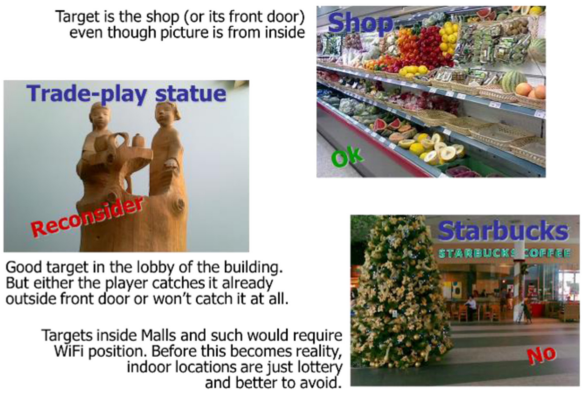


Fig. 16. Indoor targets are usually not accessible. In the future when positioning technology matures this can change.

5.3 Location Clarity

In *O-Mopsi*, a target is accepted as visited once the player is within 20 meters of the recorded location [3]. This acceptance is confirmed by playing a brief fanfare. Some games require explicit confirmation, such as a photo of the target [15] or asking questions to which the answer can be found only within the vicinity of the target [23]. *Geo-Caching* uses this option a lot. For example, a question can be "*what year is on the memorial statue*". *O-Mopsi* has only ever used or considered automatic recognition. In this section, we discuss how this impacts target creation. The following cases—at the least—must be considered:

- Big buildings
- Photo-taking location vs. actual location
- Clarity of media content
- Positional accuracy

Big buildings pose a challenge for automated target acceptance. One problem is that the player must reach an exact location (within 20 meters). However, in cases of big buildings, this is not large enough, and it may not be clear to players where they should go. Another problem is that the position of the photo is typically automatically recorded at the location where the photo was taken—not the location of the target itself.

There are a few potential solutions to the first problem. One is to select a smaller detail from the target, such as a statue near the front door of the building (Science Park) or the sacristy door (Sakasti) of the church (see Figure 17). Sometimes, it may still be okay to have an entire object as a target when it is obvious that the player is expected to visit the front door. A few tricks can be applied to achieve this implication. First, the picture of Kol Sherif (cathedral in Kazan, Russia) in Figure 18 is taken in such a way, with an upward angle, that reaching its viewpoint requires the player to get near the front door. Second, the picture of Hotel du Theater (hotel in Zürich) contains a musical key, which is visible only at the front door; the player cannot find this relief without being at the correct spot.

For the second problem, the solution is a manual fix (see Figure 19). In the case of the tall spruce, the player may reach the target, but the game may not recognize the arrival if the target is approached from the opposite direction. Alternatively, the visit may be recognized prematurely if approached from the photo-taking direction. In the case of the bridge, putting the location on one end of the bridge would mean that its recognition clearly depends on the direction from which it is approached. Thus, putting the location in the middle of the bridge is likely the best compromise.

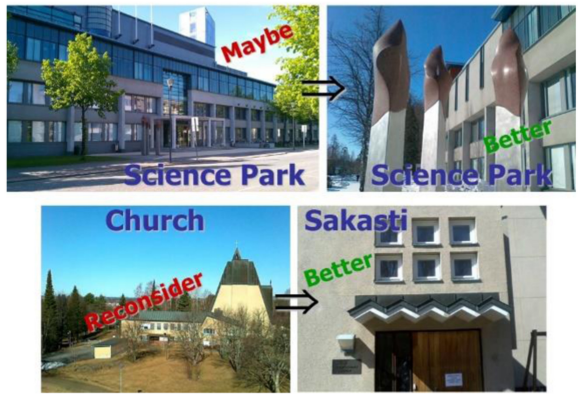


Fig. 17. Large buildings as targets pose challenges. Choosing smaller objects near large buildings is one possible tactic.

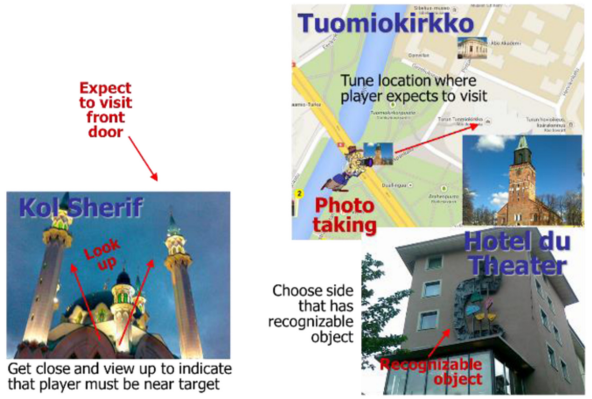


Fig. 18. The positioning problem of big buildings can be handled by choosing suitable viewpoints so that it is obvious from the picture where players are supposed to go.

Beyond distant pictures, Figure 20 presents some other position-related problems. The first picture depicts a nice sunset, but the actual target is entirely unclear. In fact, the actual image is of Joensuu Areena—not Science Park as is falsely marked. This example shows the clear need for quality control in cases of user-generated content. In case of Mansikkasaari (Strawberry Island), it is not clear whether the player is meant to visit the island in which the picture is taken, or the red building across the strait. Clarity is an important consideration when designing targets.

5.4 Identifiability

Figure 21 shows examples of unclear targets. Three of the pictures were taken without even visiting the target. Palloilukeidas (sports oasis) may have been taken for different purposes, or the user just wanted to keep their shoes dry. The motivation behind the Art Museum and Pizza Special pictures was merely fast content creation to obtain rewards for crowdsourced data collection without considering quality. Tiiliseinä (brick wall) may serve as a valid target; its image is a puzzle-like picture that is seemingly unclear but becomes apparent once the player has reached the target. The image also suffers from a secondary issue of having extremely high camera resolution, causing

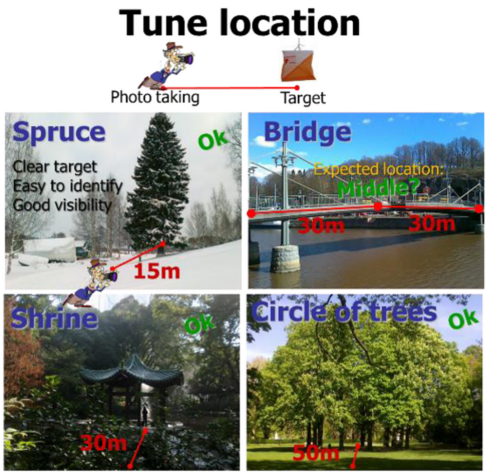


Fig. 19. Examples of targets that are well described by a distant photo but where the photo-taking position differs significantly from the target position. These all require manual adjustments.

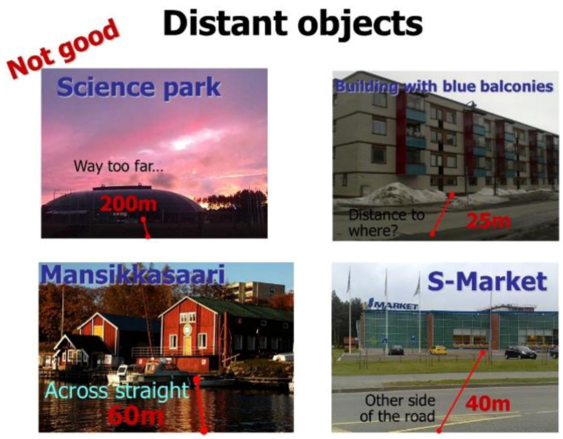


Fig. 20. Examples of problematic targets stemming from a lack of clarity or accessibility.

delays for users due to long downloading time of the target information. All these cases demonstrate the importance of quality control in reward-based crowdsourcing.

Section 5.3 considered the case of an overly large target, but small targets can also be problematic. Since visits are digitally recorded using a 20-meter threshold, players can reach a target in the game before actually seeing it. Thus, being identifiable cannot be a purpose in and of itself. For example, small details in Figure 22 could be used in the target names, but only if the picture would show the, for example, entire statue (Memorial statue) or service box (Pömpeli). In other words, the combination of the name and picture making the target identifiable is sufficient even if they would not do so individually. The third example (Oak) is also too small. It will either grow big or die; in both cases, the picture eventually becomes outdated.

Examples of suitable targets for treasure-hunt games—"recognizable objects"—are shown in Figure 22. All of them must be searched for a bit but will ultimately become visible once a player approaches their vicinity. This adds to the challenge and makes them good targets in puzzle-like

Fig. 21. Examples of unclear targets that occur when using crowdsourcing without proper quality control.

Fig. 22. Examples of overly small details (unidentifiable objects) not visible from 20 meters away versus examples of identifiable objects.

games. Some of them may pose problems related to their lifetime though. For example, mailboxes are slowly becoming outdated and expected to disappear sooner or later, while the wheel was a decoration adorning a private house and has been already removed at the time of writing this paper.

Fig. 23. Examples of natural objects that have been used as targets. In some cases, the view is unique, in other cases, the name is vital. Sometimes, their combination makes the target identifiable.

Sometimes, it may not be easy to find any easily identifiable targets in the local area. This is especially true when it comes to natural objects (see Figure 23). None of the targets is clearly recognizable without a context. Portofino (Italy) is a spot along hilly forest trails where it is basically impossible (or at least dangerous) to deviate from the designated trail. For this reason, the target will simply be found by following the trail—it is effectively impossible to miss given the scene. The Water spring (Vadodara, India) also relies on seeing it from the certain perspective. Kowloon Park (Hong Kong) is large, but the picture only depicts the park's entrance, making it a unique location.

Sometimes, an image alone is not sufficient to identify a target. However, a target can be made identifiable by considering the description that comes alongside its image. For example, the name Under maple tree could not effectively guide a player to a complete tree; however, a player can consider the perspective depicted in the picture and find the spot from which it was taken, ultimately bringing them underneath a maple tree and able to identify the target. Sometimes, there is no chance to identify a target, and the only choice is to describe the surrounding and expect the player simply to reach the marked location. For example, the Maple tree is just one of many such trees, and the trail along which it resides continues throughout the forest. However, since nothing else is around that tree, such compromises sometimes need to be made, with players forced to reach precise locations without being guided by any unique landmark.

5.5 Lifetime of a Target

The lifetime of a target must be considered, especially for tours that are not constantly monitored and updated. Figure 24 presents a few examples. The lifetimes of cafés and restaurants are surprisingly short. While popular and well-established chains may exist for a long time, most new ones survive only a year or a few years. Vero Café (Klaipeda, Lithuania) in the picture is one of the rare examples; it has been operational since 2012. Tours designed for short-term events like SciFest can even use temporary objects like snow, which melts fast even in Finland. The target Grafiti is already removed as graffiti in general are not tolerated in most cities. Cars in private settings can be moved at the owner's discretion without notice. Finally, questions about whether a flag is hanging at Cinquantenaire Park in Brussels everyday requires local knowledge.

The issue of lifetime is less critical if the content is regularly monitored. One difficulty for player review is that players cannot review target content without actually visiting that target [2]. Another issue is that the review rate is usually low. More than 50% of targets in general garner no reviews whatsoever according to [6]. Missing targets should be easy to recognize and report.

Fig. 24. The lifetime of an object is an issue that must be considered. All the target examples are here are attractive and easily recognizable, but do they still exist tomorrow?

However, frustrated players are more likely to just quietly walk away instead of sending error reports. For these reasons, the lifetime of targets should be considered already when the target is created.

6 VALIDATION OF THE PRINCIPLES

To validate the proposed design principles, we conducted a small-scale survey (five participants) familiar with *O-Mopsi* either as a developer or player. We sent invitations via email, and participants could complete the survey remotely on their own time. There were no financial (or any other kind of) incentives to complete the survey. The participants joined mainly due to their interest in the topic, loyalty to the development team, or willingness to support research.

The participants were presented with 45 target examples from this paper in no specific order and asked to rate all of them. One participant only rated 35 targets. They were asked to identify which of the five design principles applies to each target. The participants had no prior knowledge of the design principles. The interface of the web survey is shown in Figure 25.

We counted the votes that each target received for each principle, resulting in a number from 0 to 5 based on how many of the respondents had selected this principle for the target. We then compared the results with our presumption of each target's fit with the principles. For example, we expected all of the examples in Figure 23 to not meet the long-lifetime principle and, in turn, to receive low scores on this principle. Below, we summarize the main observations from the survey.

Attractiveness: All the targets listed as examples of attractiveness example received 2 votes or more. Especially statues and sightseeing landmarks all received 4 or 5 votes. The residential buildings and shops, however, received only 0 or 1 vote. Despite this, they all were used in real games and considered useful for gameplay purposes even if not rated as attractive.

Accessibility: Only three examples violating this principle were shown. However, the survey participants did not identify with this principle, as two of these targets (Trade Play Statue and Starbucks) were given 3 votes. Shop received only 1 vote. The responses would have likely been different had more obviously problematic safety-related examples (e.g., a highway) been provided.

Clarity of location: We provided 13 examples from Section 5.3. The clearly distant targets (Art Museum, Portofino) and target (Mansikkasaari) received few votes (0 or 1), but the other

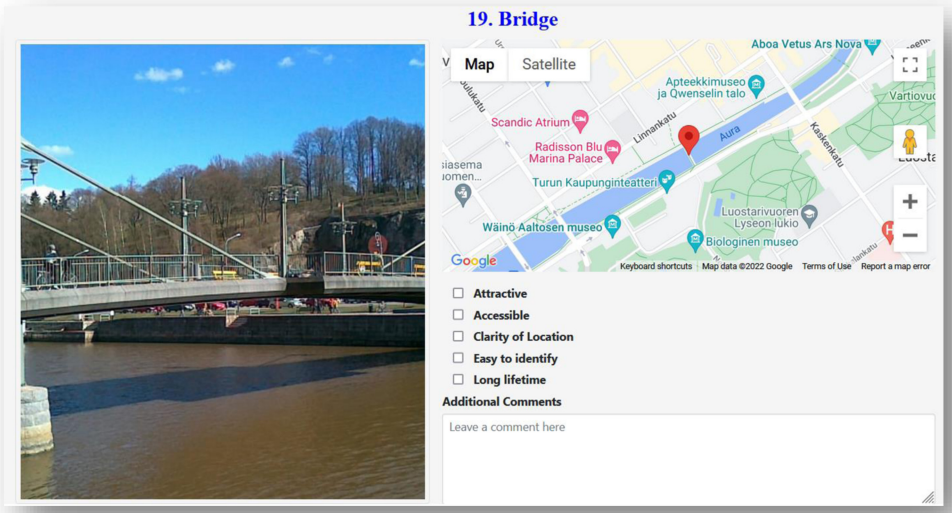


Fig. 25. Sample target in the web survey. Participants clicked the principles that they felt applied to this target.

examples from Figure 19 each received 3 votes, meaning that they did not raise concern. The examples assumed to be good, all received 3 or 4 votes with the exception of Spruce (1 vote), which was thought to be unclear. A few other examples assumed to be bad cases for the next principle, received a low number of votes. Otherwise, the survey results confirmed well the principle.

Identifiability: Section 5.4 contains 18 examples in total. This was the least agreed-upon principle, as all targets received votes even if it was only used as a counterexample. The only exceptions confirming the principle were Pömpeli and Tiiliseinä (brickwall). One reason for this is that we selected examples from real games and, despite them being imperfect, they were deemed to be good enough. Another reason is that all participants were local and knew local places already (which constituted 7 of the 18 examples), which may have influenced their votes. Furthermore, as this principle is strongly correlated to location clarity (Pearson = 0.75), we conclude that this principle is likely redundant.

Lifetime of a target: This was the most agreed-upon principle. Of the six examples in Section 5.5, five received no votes at all. The only exception is the Vero Café, which received two votes. This is understandable, as it still exists. The other short-lifespan examples (*Leaf* and Wheel) from the other principles did not receive any votes either. In contrast, all other targets received some votes: 0.33 on average.

In summary, the lifetime of a target and location clarity were the most agreed-upon principles among the survey respondents despite them rarely being considered in the literature [2, 6]. Accessibility has received the most attention in the literature [2, 10, 31, 48, 56] but was hardly addressed in our survey. One reason for this is that the data lacked blatantly unsafe locations, and the game creators considered this principle to be adequately implicit. Furthermore, the indoor targets were not considered to be an issue, with players seemingly assuming that indoor targets function well enough. Most *O-Mopsi* games and targets were created in an era in which accurate positioning relied mainly on GPS signal, and indoor targets were to be avoided.

7 CONCLUSIONS

We have presented a carefully selected set of design principles for high-quality content creation in treasure-hunt location-based games and sightseeing tours. An enjoyable gaming experience largely depends on content quality, which requires developers to be aware of common design pitfalls. This paper focused on individual targets, meaning that it did not address overall target layout and game design. The proposed design principles were derived from our experience running the *O-Mopsi* orienteering game over the years.

A target normally comprises three elements: name, location, and media content. The name of the target should be short and capture the essence of the target. The location can be any landmark or easily identifiable object. The media content can be an image or even a short video. While anyone can take pictures, only an experienced content creator or application expert may know all the criteria to generate high-quality content. Knowing a local area is not enough; aesthetic sense is also required. We introduced five key design principles to consider while crafting in-game targets: attractiveness, accessibility, location clarity, identifiability, and lifetime of a target.

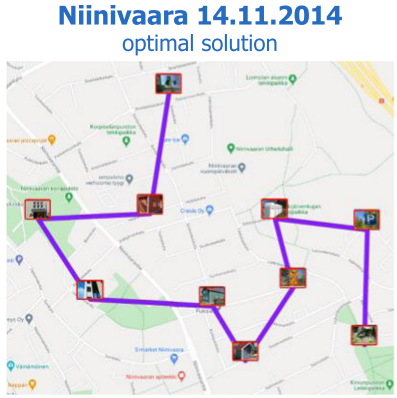
Targets do not need to be large landmarks so long as they are recognizable objects, such as statues, guiding signs, or even nameplates. Target location requires serious consideration, especially in cases of big buildings. To avoid player frustration in terms of finding the right way to approach the building, using smaller details near the building or a notable part of a building rather than the whole building is recommended. Location may require manual tuning, as the photo spot and the actual location may differ significantly. Forbidden or dangerous areas like private yards and highways must be avoided.

Targets should also be easy to identify. Overly small targets are discouraged, as players may reach them before even seeing them. A target should be visible once a player is in its vicinity. Placing targets indoors is not recommended, as GPS signals often perform poorly indoors. The lifetime of a target must also be considered. Tours designed for short-term events can use temporary objects, but targets used in normal long-term tours require regular monitoring by developers or players. Of course, continuous support from players is only possible once the game reaches a certain level of maturity.

The main limitation of the proposed principles is that they may not be sufficiently concrete for inexperienced content creators. Not everyone is born with an understanding of effective style, especially given that style is inherently subjective. Design skills are still necessary. However, through these design principles, one can still avoid the biggest mistakes in content creation, increasing their chances of garnering positive user experiences through the provision of high-quality content. The principles could be more concrete to guide users in the creation of high-quality content. For future work, we aim to implement the proposed principles in a real game environment.

APPENDIX

The optimal solution for the task given in Section 3.



REFERENCES

[1] S. Hajarnis, B. Headrick, A. Ferguson, and M. O. Riedl. 2011. Scaling mobile alternate reality games with geo-location translation. In *International Conference on Interactive Digital Storytelling*. Springer, Berlin. 278–283. https://doi.org/10.1007/978-3-642-25289-1_30

[2] C. Neustaedter, A. Tang, and T. K. Judge. 2013. Creating scalable location-based games: Lessons from geocaching. *Personal and Ubiquitous Computing* 17, 2 (2013), 335–349. https://doi.org/10.1007/s00779-011-0497-7

[3] P. Fränti, R. Mariescu-Istodor, and L. Sengupta. 2017. *O-Mopsi*: Mobile orienteering game for sightseeing, exercising, and education. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM)* 13, 4 (2017), 1–25. https://doi.org/10.1145/3115935

[4] C. Pang, R. Pan, C. Neustaedter, and K. Hennessy. 2019. City explorer: The design and evaluation of a location-based community information system. *CHI Conference on Human Factors in Computing Systems*. 1–15. https://doi.org/10.1145/3290605.3300571

[5] M. Lu and M. Arikawa. 2015. Creating geo-enabled hand-drawn maps: An experiment of user-generated mobile mapping. *International Journal of Cartography* 1, 1 (2015), 45–61. https://doi.org/10.1080/23729333.2015.1055110

[6] S. Matyas, P. Kiefer, C. Schlieder, and S. Kleyer. 2011. Wisdom about the crowd: Assuring geospatial data quality collected in location-based games. *Int. Conf. on Entertainment Computing*. Springer, Berlin. 331–336. https://doi.org/10.1007/978-3-642-24500-8_36

[7] Pocket Tactics. 2021. The best location-based games on mobile. *Pocket Tactics*. Retrieved Jan. 11, 2021 www.pockettactics.com/best-location-based-games mobile.

[8] Will Fulton. 2020. The best location-based GPS games. *Digital Trends*. Retrieved Nov. 21, 2020 https://www.digitaltrends.com/gaming/best-location-based-gps-games/.

[9] Hal Hodson. 2012. Google's Ingress game is a gold mine for augmented reality. *New Scientist* 216, 2893 (2012), 19. https://doi.org/10.1016/S0262-4079(12)63058-9

[10] S. Laato, T. Pietarinen, S. Rauti, M. Paloheimo, N. Inaba, and E. Sutinen. 2019. A review of location-based games: Do they all support exercise, social interaction and cartographical training. *Int. Conf. on Computer Supported Education (CSEDU 2019)*. 616–627. https://doi.org/10.5220/0007801206160627

[11] J. Nery Filho and A. I. Veloso. 2019. Location-based games on active aging: A systematic review. *Iberian Conference on Information Systems and Technologies (CISTI)*. IEEE. 1–6. https://doi.org/10.23919/CISTI.2019.8760640

[12] A. Bengs, S. Hägglund, A. Wiklund-Engblom, and S. Staffans. 2015. Designing for suburban social inclusion: A case of geo-located storytelling. *IxD & A* 25 (2015), 85–99.

[13] V. Kasapakis and D. Gavalas. 2017. User-generated content in pervasive games. *Computers in Entertainment (CIE)* 16, 1 (2017), 1–23. https://doi.org/10.1145/3161570

[14] P. Alavesa and T. Ojala. 2015. Street Art Gangs: Location based hybrid reality game. In *Proceedings of the 14th International Conference on Mobile and Ubiquitous Multimedia*. 64–74. https://doi.org/10.1145/2836041.2836047

[15] M. Lochrie, K. Lund, and P. Coulton. 2010. Community generated location-based gaming. *Proceedings of HCI 2010* 24 (2010), 474–478. https://doi.org/10.14236/ewic/HCI2010.59

[16] V. Kasapakis and D. Gavalas. 2016. Investigating the effect of user generated content in pervasive games. *IEEE Symposium on Computers and Communication (ISCC)*. 79–84. https://doi.org/10.1109/ISCC.2016.7543718
[17] R. Wetzel, L. Blum, and L. Oppermann. 2012. Tidy City: A location-based game supported by in-situ and web-based authoring tools to enable user-created content. *Int. Conf. on the Foundations of Digital Games*. 238–241. https://doi.org/10.1145/2282338.2282385
[18] S. Benford, D. Rowland, M. Flintham, R. Hull, J. Reid, J. Morrison, and B. Clayton. 2004. Savannah: Designing a location-based game simulating lion behaviour. *Int. Conf. on Advances in Computer Entertainment Technology*.
[19] J. C. Puja and D. Parsons. 2011. A location-based mobile game for business education. In *2011 IEEE 11th International Conference on Advanced Learning Technologies*. IEEE. 42–44.
[20] H. Tuzun, M. Yylmaz-Soylua, T. Karakuþb, Y. Ynalb, and G. Kyzylkayaa. 2009. The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education* 52, 1 (2009), 68–77. https://doi.org/10.1016/j.compedu.2008.06.008
[21] N. Nova, F. Girardin, and P. Dillenbourg. 2005. 'Location is not enough!': An empirical study of location-awareness in mobile collaboration. In *IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'05)*. IEEE. 21–28. https://doi.org/10.1109/WMTE.2005.2
[22] D. La Guardia, M. Arrigo, and O. Di Giuseppe. 2012. A location-based serious game to learn about the culture. *Int. Conf. on The Future of Education* (2nd ed.). 508–512. https://doi.org/10.1007/s10055-010-0177-3
[23] K. Vassilakis, O. Charalampakos, G. Glykokokalos, P. Kontokalou, M. Kalogiannakis, and N. Vidakis. 2018. Learning by playing: An LBG for the fortification gates of the Venetian walls of the city of Heraklion. *EAI Endorsed Transactions on Creative Technologies* 5, 16 (2018). https://doi.org/10.4108/eai.7-3-2019.156773
[24] J. Huizenga, W. Admiraal, S. Akkerman, and G. T. Dam. 2009. Mobile game-based learning in secondary education: Engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning* 25, 4 (2009), 332–344. https://doi.org/10.1111/j.1365-2729.2009.00316.x
[25] J. D. Wake and R. Baggetun. 2009. Premierløytnant bielke: A mobile game for teaching and learning history. *International Journal of Mobile and Blended Learning (IJMBL)* 1, 4 (2009), 12–28.
[26] K. P. Chang, Y. W. Huang, S. Y. Hsueh, Y. T. Chen, S. N. Huang, C. H. Chen, and S. F. Chien. 2014. Hidden Lion: A location-based app game of sword lion searching. *ACM SIGCHI Annual Symposium on Computer-Human Interaction in Play*. 323–326. https://doi.org/10.1145/2658537.2662975
[27] C. Sintoris, A. Stoica, I. Papadimitriou, N. Yiannoutsou, V. Komis, and N. Avouris. 2012. MuseumScrabble: Design of a mobile game for children's interaction with a digitally augmented cultural space. Social and organizational impacts of emerging mobile devices: Evaluating use. *IGI Global*. 124–142. https://doi.org/10.4018/jmhci.2010040104
[28] T. H. Laine, C. I. Sedano, M. Vinni, and E. Sutinen. 2009. Uncovering the richness of an authentic living museum through pervasive learning environment. In *2009 Ninth IEEE International Conference on Advanced Learning Technologies*. IEEE, 655–657. https://doi.org/10.1109/ICALT.2009.57
[29] E. Klopfer, J. Perry, K. Squire, M. F. Jan, and C. Steinkuehler. 2005. Mystery at the Museum–a collaborative game for museum education.
[30] V. Kasapakis and D. Gavalas. 2016. Investigating the effect of user generated content in pervasive games. *IEEE Symposium on Computers and Communication (ISCC)*. 79–84. https://doi.org/10.1109/ISCC.2016.7543718
[31] L. Oppermann and M. Slussareff. 2016. Pervasive games. Entertainment computing and serious games. *Lecture Notes in Computer Science*, vol. 9970. Springer, Cham. https://doi.org/10.1007/978-3-319-46152-6_18
[32] C. Ferreira, L. F. Maia, C. de Salles, F. Trinta, and W. Viana. 2019. Modelling and transposition of location-based games. *Entertainment Computing* 30 (2019), 100295. https://doi.org/10.1016/j.entcom.2019.100295
[33] S. Casey, B. Kirman, and D. Rowland. 2007. The Gopher game: A social, mobile, locative game with user generated content and peer review. In *Proceedings of the International Conference on Advances in Computer Entertainment Technology*. 9–16. https://doi.org/10.1145/1255047.1255050
[34] E. Massung, D. Coyle, K. F. Cater, M. Jay, and C. Preist. 2013. Using crowdsourcing to support pro-environmental community activism. *SIGCHI Conference on Human Factors in Computing Systems*. 371–380. https://doi.org/10.1145/2470654.2470708
[35] M. Bell, S. Reeves, B. Brown, S. Sherwood, D. MacMillan, J. Ferguson, and M. Chalmers. 2009. EyeSpy: Supporting navigation through play. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 123–132.
[36] D. H. L. Goh, E. P. P. Pe-Than, and C. S. Lee. 2016. Crowdsourcing mobile content through games: An analysis of contribution patterns. *Proceedings of the Association for Information Science and Technology* 53, 1 (2016), 1–10. https://doi.org/10.1002/pra2.2016.14505301061
[37] M. N. Giannakos and L. Jaccheri. 2013. What motivates children to become creators of digital enriched artifacts? In *Proceedings of the 9th ACM Conference on Creativity & Cognition*. 104–113. https://doi.org/10.1145/2466627.2466634
[38] D. C. Ukpabi and H. Karjaluoto. 2018. What drives travelers' adoption of user-generated content? A literature review. *Tourism Management Perspectives* 28 (2018), 251–273. https://doi.org/10.1016/j.tmp.2018.03.006

[39] M. N. Giannakos and L. Jaccheri. 2018. From players to makers: An empirical examination of factors that affect creative game development. *International Journal of Child-Computer Interaction* 18 (2018), 27–36. https://doi.org/10.1016/j.ijcci.2018.06.002
[40] E. FitzGerald. 2012. Creating user-generated content for location-based learning: An authoring framework. *Journal of Computer Assisted Learning* 28, 3 (2012), 195–207. https://doi.org/10.1111/j.1365-2729.2012.00481.x
[41] T. Cochrane. 2016. Mobile VR in education: From the fringe to the mainstream. *International Journal of Mobile and Blended Learning (IJMBL)* 8, 4 (2016), 44–60. https://doi.org/10.4018/978-1-5225-5469-1.ch014
[42] S. Matyas, C. Matyas, C. Schlieder, P. Kiefer, H. Mitarai, and M. Kamata. 2008. Designing location-based mobile games with a purpose: Collecting geospatial data with CityExplorer. *Int. Conf. on Advances in Computer Entertainment Technology*. 244–247. https://doi.org/10.1145/1501750.1501806
[43] C. Neustaedter and K. Judge. 2011. *Searching and Content Creation in a Location-based Treasure Hunt Game* Technical Report 2011-1116-02, Connections Lab, Simon Fraser University, Surrey, BC, Canada, November.
[44] I. Celino, S. Contessa, M. Corubolo, D. Dell'Aglio, E. Della Valle, S. Fumeo, and T. Krüger. 2012. Linking smart cities datasets with human computation–the case of UrbanMatch. *International Semantic Web Conference*. Springer, Berlin. 34–49. https://doi.org/10.1007/978-3-642-35173-0_3
[45] C. Erlacher, G. Paulus, S. Andrae, G. Lehrer, G. Gruber, P. Moser, and A. Schimanz. 2012. OpenPOI–location-based applications to collect free point-of-interest data for secondary school students. *GI_Forum*, 230–239.
[46] J. Schito, C. Sailer, and P. Kiefer. 2015. Bridging the gap between location-based games and teaching. In *AGILE 2015 Workshop on Geogames and Geoplay. ETH Zürich*. https://doi.org/10.13140/RG.2.1.1322.3844/1
[47] K. Heljakka and P. Ihamäki. 2018. Designing a pervasive adventure gamescape: Avoiding the pitfalls in creating augmented LBGs for playful learning. *Journal of Digital Media & Interaction* 1, 2 (2018), 75–94. https://doi.org/10.34624/jdmi.v1i2.955
[48] A. Kultima. 2009. Casual game design values. *International MindTrek Conference: Everyday Life in the Ubiquitous Era*. 58–65. https://doi.org/10.1145/1621841.1621854
[49] H. Söbke, J. B. Hauge, and I. A. Stefan. 2017. Prime example Ingress reframing the pervasive game design framework (PGDF). *International Journal of Serious Games* 4, 2 (2017). https://doi.org/10.17083/ijsg.v4i2.182
[50] S. Scheider and P. Kiefer. 2018. (Re-) localization of location-based games. *Geogames and Geoplay*. Springer, Cham. 131–159. https://doi.org/10.1007/978-3-319-22774-0_7
[51] D. Polson, S. Huang, and C. Morgan. 2007. Cipher cities: Effective user interface design for building a digital social network around location-based gaming. *Int. Conf. on Mobile Technology, Applications, and Systems and the 1st International Symposium on Computer Human Interaction in Mobile Technology*. 614–618. https://doi.org/10.1145/1378063.1378165
[52] L. Sengupta and P. Fränti. 2021. Measuring the difficulty of a TSP instance by MST branches. *AIMS Applied Computing and Intelligence* 1, 1 (2021), 1–32.
[53] I. Bindoff, K. de Salas, G. Peterson, T. Ling, I. Lewis, L. Wells, and S. G. Ferguson. 2016. Quittr: The design of a video game to support smoking cessation. *JMIR Serious Games* 4, 2 (2016), e19. https://doi.org/10.2196/games.6258
[54] C. Neustaedter and T. K. Judge. 2012. See It: A scalable location-based game for promoting physical activity. *ACM 2012 Conference on Computer Supported Cooperative Work Companion*. 235–238. https://doi.org/10.1145/2141512.2141586
[55] P. Caserman, K. Hoffmann, P. Müller, M. Schaub, K. Straßburg, J. Wiemeyer, and S. Göbel. 2020. Quality criteria for serious games: Serious part, game part, and balance. *JMIR Serious Games* 8, 3 (2020), e19037. https://doi.org/10.2196/preprints.19037
[56] J. Arango-López, F. L. Gutiérrez Vela, C. A. Collazos, J. Gallardo, and F. Moreira. 2021. GeoPGD: Methodology for the design and development of geolocated pervasive games. *Universal Access in the Information Society* 20, 3 (2021), 465–477.
[57] https://education.mit.edu/project/taleblazer. (Accessed 19th December 2022).
[58] I. Andone, K. Blaszkiewicz, M. Böhmer, and A. Markowetz. 2017. Impact of location-based games on phone usage and movement: A case study on Pokémon GO. In *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services*. 1–8.
[59] C. Budak, D. Agrawal, and A. El Abbadi. 2011. Limiting the spread of misinformation in social networks. In *Proceedings of the 20th International Conference on World Wide Web*. 665–674.
[60] S. Zannettou, T. Caulfield, E. De Cristofaro, N. Kourtelris, I. Leontiadis, M. Sirivianos, and J. Blackburn. 2017. The web centipede: Understanding how web communities influence each other through the lens of mainstream and alternative news sources. In *Proceedings of the 2017 Internet Measurement Conference*. 405–417.
[61] https://niantic.helpshift.com/hc/en/21-wayfarer/faq/2771-acceptance-criteria/. (Accessed 19th December 2022).
[62] N. Alderman. 2012. Zombies, Run! http://researchspace.bathspa.ac.uk/1376/. (Accessed 19th December 2022).
[63] E. Klopfer and K. Squire. 2008. Environmental detectives—the development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development* 56, 2 (2008), 203–228.

[64] R. Lobb. 2013. CodeRunner. Available at https://github.com/trampgeek/CodeRunner. (Accessed 19th December 2022).
[65] Ludia Inc. https://jurassicworldalive.com/. (Accessed 19th December 2022).
[66] https://www.randonautica.com/. (Accessed 23rd January 2023)
[67] A. Ruiz-Ariza, S. López-Serrano, S. Suárez-Manzano, and E. J. Martínez-López. 2020. The educational use of the 'Harry Potter: Wizards Unite' augmented reality application. In *Augmented Reality in Education*. 247–259. Springer, Cham.
[68] S. Laato, T. Pietarinen, S. Rauti, and T. H. Laine. 2019. Analysis of the quality of points of interest in the most popular location-based games. In *Proceedings of the 20th International Conference on Computer Systems and Technologies*. 153–160.

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