Telematics and Informatics 65 (2021) 101716

Contents lists available at ScienceDirect

Telematics and Informatics

journal homepage: www.elsevier.com/locate/tele

Convergence between the real and the augmented: Experiences and perceptions in location-based games

Samuli Laato [a,c,*], Nobufumi Inaba [b], Juho Hamari [a]

[a] Gamification Group, Faculty of Information Technology and Communication Sciences, Tampere University, Finland
[b] School of Language and Translation, University of Turku, Finland
[c] Department of Computing, University of Turku, Finland

ARTICLE INFO

Keyword:
Location-based games
Geo games
Point of interest
Augmented reality
AR

ABSTRACT

Location-based augmented reality (AR) games have recently become massively popular, generating billions of dollars in revenue during the past five years. These games augment geographical areas with playful content, which makes the playing experience dependent on both the game and the playing location. Existing games have employed various methods for increasing the connection between the game and the physical world, such as (1) an AR mode that lets players see virtual objects in the physical world through the lens of their mobile device; and (2) connecting the game's virtual points of interest (PoIs) to physical world objects. To explore how these influence the playing experience, we surveyed players (N = 74) across four popular location-based AR games. We analyzed the data using a thematic clustering approach, which resulted in five central themes. Among our findings was that only 7% of the surveyed players regularly used or appreciated AR features that made use of the mobile device's camera. The most often given reason for this was that they slow down progression. By contrast, players appreciated location-based features and the augmentation of digital content on a map interface. Connecting the virtual content to physical world objects was seen to have the benefits of (1) supporting social meetings; (2) enabling learning about the real world; and (3) increasing the meaningfulness of the virtual content.

1. Introduction

Location-based AR games, also referred to as location-based games (LBGs), combine location features and augmented reality (AR) to bring about a game world that is connected to the real world (Hamari et al., 2018; Rauschnabel et al., 2017). LBGs emerged in the early 2000's due to technological developments in mobile devices, internet infrastructure and location sensors (Leorke, 2018). Today, LBGs have reached an enormous player market, with the currently most popular LBG Pokémon GO surpassing 3.6 billion USD in revenue during its first four years after launch (Chapple, 2020). Besides booming monetary success, LBGs have been reported to have a positive impact on players, for example, on their social well-being (Lee et al., 2021; Ruiz-Ariza et al., 2018) and physical activity (Lee et al., 2021; Khamzina et al., 2020). Subsequently, health practitioners have been interested in LBGs and their potential for increasing the well-being of individuals (Althoff et al., 2016; Hino et al., 2019). LBGs have also shown potential in teaching players about real world places and environments (Oleksy and Wnuk, 2017). This has attracted the attention of educators who have investigated ways to

* Corresponding author.
E-mail address: samuli.laato@tuni.fi (S. Laato).

https://doi.org/10.1016/j.tele.2021.101716
Received 31 May 2021; Received in revised form 9 August 2021; Accepted 14 September 2021
Available online 20 September 2021

make use of LBGs in primary, secondary and tertiary education (e.g. Fonseca et al., 2020; Mozelius et al., 2017; Mozelius et al., 2019; Remmer et al., 2017).

The beneficial aspects of exercise and social interaction in LBGs are tied to the physical playing location, and in particular to the in-game points of interest (PoIs) to which the LBG players are prompted to navigate. This makes investigating the role and impact of PoIs in LBGs important from both a theoretical and practical perspective, as they have a holistic impact on the playing experience. In cases where the virtual PoIs are tied to existing real world objects, the games can facilitate learning about the physical world environment better than with PoIs disconnected from the real world (Laato et al., 2019). However, studies have shown that linking PoIs to important real world objects causes rural areas to have less PoIs, thus- potentially discriminating against people living in low-income areas lacking cultural hotspots (Juhász and Hochmair, 2017). Scholars have proposed several solutions to address this situation, including the use of different PoI criteria for rural areas (Tregel et al., 2017).

Recent work has argued that PoIs corresponding to real world locations are generally safer and afford more immersive gameplay than randomly placed PoIs (Laato et al., 2019). However, the importance of linking in-game PoIs to physical world locations remains unexplored from the perspective of game enjoyment and a sense of meaningfulness of playing. Furthermore, it remains open whether LBG design should aim for as fastidious a fusion between reality and the game world as possible. While several LBGs provide players with an AR-mode to support their imagination and to increase the link between the game and reality, little research has been conducted on this topic from the players' perspective. Furthermore, recent work has suggested that AR has the potential to start replacing physical objects in the near future (Rauschnabel, 2021), but whether AR content can already "feel real" for LBG players remains unanswered. To address these research gaps, we propose the following research questions that guide this study:

RQ1. What is the role of the AR-mode in LBG players' imagination, enjoyment and overall experience?
RQ2. How important is the linkage between virtual PoIs and physical world objects for LBGs players' experience?

To address these research questions we conducted interviews and an online survey with players across four currently popular LBGs: Pokémon GO, Harry Potter: Wizards Unite (HPWU), The Walking Dead: Our World (WDOW) and Orna. We asked about the players' perceptions, thoughts and ideas related to the thematic areas indicated by the research questions. The remainder of this study is structured as follows. First, we review previous literature on our research topic. We then present the research methodology of the current study followed by our findings. We discuss our results and their implications before presenting limitations, conclusions and directions for future work.

2. Previous work

Research on the connection of LBGs to the real world has been conducted on several levels. On a broad level, research on AR user experiences has focused on aspects of AR design that make it emotionally rewarding for players (Dirin and Laine, 2018; Irshad and Rambli, 2014). Dirin and Laine (2018) stressed the importance of AR-technologies having (1) spatial correspondence; (2) tolerance to movement; and (3) object detail. In other words, AR-technologies should aim for a seamless usability and integration with the real world. In the context of LBGs, there are several ways for designers to reach this goal. These include the opportunity to take AR-photos and share them online (Alavesa and Xu, 2020), connecting LBG play content to real world places (Laato et al., 2019), providing interfaces that are intuitive to use (Dirin and Laine, 2018), and involving other people in the game to create shared social experiences in the real world (Bhattacharya et al., 2019). Furthermore, one of the reasons players play LBGs is to enjoy outdoor activity (Hamari et al., 2018), which also speaks of the benefits of interlinking the gameworld with aspects of the real world.

A high level of convergence between LBGs and the physical world can lead to the game influencing player movement in the real world, even permanently (Colley et al., 2017). Furthermore, players may grow attached to virtual territory to the extent that they are willing to obsessively defend it in the game world (Papangelis et al., 2017; Papangelis et al., 2020). It is not only virtual territory that players grow attached to, but also the corresponding real world places (Oleksy and Wnuk, 2017). But while LBGs have this capability to influence player behavior and movement with PoI placement, the topic is still understudied. Recent work suggests that players enjoy a wide variety of PoIs that are linked to the real world, including technical and cultural PoIs (Wolf et al., 2020), but further work is needed on how the quality of PoIs influences players' playing experiences (Laato et al., 2019).

Jensen et al., (2019) conceptualize LBGs as additional layers of reality which could invoke in players ruminations that the virtual world is present and can be accessed. As the human brain is attuned to remembering locations of food sources (Nairne et al., 2009), it can be suggested that LBG players would be more likely to remember real world locations where they find virtual goods. As a consequence of playing the LBG Ingress, more than 96% of players reported to have experienced automatic mental processes related to the game outside the immediate playing context (Sifonis, 2019). Due to the minimal focus on music in the game, unsurprisingly, players did not hear Ingress music outside the game, nor did they have altered visual perceptions (Sifonis, 2019). Rather, the most common automatic game-linked thoughts related to urges to play or think about the game (Sifonis, 2019). This finding on its own does not yet differentiate LBGs from other games, and in fact, the lack of altered visual perceptions suggests that LBGs might not be able to influence players' perceptions of reality outside the game context any more than other video games. However, the study of Sifonis (2019) was carried out in the context of Ingress which does not have an AR mode. Thus, one important question to investigate is whether the AR mode that enables visualizing LBG content in 3D has an impact on players' altered visual perceptions of reality.

From the perspective of creating positive emotions (Dirin and Laine, 2018; Oleksy and Wnuk, 2017) and engaging players (Sifonis, 2019; Papangelis et al., 2017; Papangelis et al., 2020), the literature suggests that LBG design should aim for as holistic an integration with the physical world as possible. This is also explicitly suggested by early scholars in the field (Waern et al., 2009). However, several

research questions and gaps remain. Overall, there is a need to study how the connection of PoIs and real world places influences the playing experience. Another unexplored area relates to the use of the AR-mode in LBGs, and Alavesa and Xu (2020) recently showcased how players bring the game world into social media through sharing AR-mode screenshots. But whether LBG players feel that the AR-mode is either a gimmick or a central important part of gameplay remains unexplored. Both these questions connect to the overarching theme of the importance of connecting LBGs to the physical world.

3. Methodology

3.1. Interview protocol and survey design

In-depth interviews are a suitable approach for collecting qualitative information such as stories, facts, opinions, and participant's experiences regarding a topic or phenomena (Coombes et al., 2009). The strength of this approach is that the in-depth interview format leaves room for participants to introduce thoughts and ideas about which the researchers had no preconceptions (Coombes et al., 2009). This serves the aim of this study, which was to explore phenomena related to the connection between location-based AR games and the physical world. Accordingly, the data collection was designed to produce material to primarily answer the question of what is, rather than how much or how many (Morse, 2007).

Based on the authors' experience of playing LBGs, as well as prior research discussing aspects of the connection between LBGs and the physical world (e.g. Laato et al., 2019; Söbke et al., 2017; Papangelis et al., 2017), we wrote down LBG design elements related to the connection between the game and the real world. These included PoIs (Juhász and Hochmair, 2017; Laato et al., 2019), AR-features (Rauschnabel, 2021), real world events and gatherings related to the game (Söbke et al., 2017), and a story that encourages players to pretend as if the game world was real (Waern et al., 2009). We identified relevant research questions from the literature and from our experiences regarding these aspects, and created a skeleton of questions around these phenomena. Upon the second iteration of the questionnaire, we divided the questions into two overarching topics: (1) AR, story and imagination; and (2) PoIs and playing locations; matching the research questions of this study. These two topics and the related survey questions are shown in Appendices 1-4. In order to leave room for further topics and remarks, we also asked the participants to share stories, opinions and ideas related to the two research questions of the study. Accordingly, following guidance from the literature on in-depth interviews, we used a semi-structured interview approach and asked follow-up questions based on the participants' responses (Coombes et al., 2009).

As we were limited by the COVID-19 pandemic restrictions, we were left with two options: either to carry out a portion of the interviews online, or to ask participants to respond to the survey asynchronously. Ultimately, we prioritized gaining a more diverse set of responses and created an asynchronous online survey to supplement the interview data collection. This online survey was a copy of the semi-structured interview form with minor edits to make the questions understandable. We decided to interview and survey players across four LBGs, and consequently, the exact questions were edited slightly to match the game in question. For example, the survey on Pokémon GO asked whether players imagined the pokémon creatures in the real world, while the survey for WDOW asked whether they imagined zombies or in-game buildings in the real world. The forms for the semi-structured questionnaires used for the games in this study are available in Appendices 1-4.

3.2. Participants and data collection

To obtain data from a variety of viewpoints and to reduce the impact of sampling bias, we formulated three criteria for participant recruitment, which are displayed in Table 1. The aim of these criteria was to ensure a broad coverage of LBG players, living locations, games and playstyles in order to ensure the possibility for a broad spectrum of observations to emerge. Consequently, this enabled us to identify overarching phenomena related to the two research questions and themes of the study which are universal across LBGs, individual differences and playing locations. We recruited players of Pokémon GO which has been shown to engage players in the long-term (Söbke et al., 2019), but also three newer LBGs: HPWU, Orna and WDOW to obtain supplementary viewpoints from less popular but still widely played games. All of these games connect slightly differently to the real world. For example, in Pokémon GO and HPWU static PoIs correspond to real world objects, while in Orna and WDOW they do not. Participants were recruited from online communication channels, primarily Telegram and Facebook, as well as from meeting players physically during LBG play.

Two researchers independently conducted semi-structured face to face interviews (Coombes et al., 2009) with LBG players in Southern Finland between June 2020 - September 2020. During the first round of invitations, 12 participants joined us in interviews and gave their consent to use their responses in the research. The duration of the face to face interviews varied between 15 mins to 1 h

Table 1
Participant recruitment criteria and explanation.

Criterion	Explanation
#1 Playing experience of over a month.	We estimated that with less than one month of playing experience, players would have an inadequate understanding of the nuances of the game. However, we did not want to limit participants too much by requiring them to have played the game for longer. We also felt that the opinions of relatively new players could provide valuable insights.
#2 Players from both urban and rural areas.	Past work has shown that players from rural and urban areas experience LBGs quite differently (Juhász and Hochmair, 2017). We wanted to obtain viewpoints from both perspectives.
#3 Players from four independent LBGs.	While Pokémon GO is the most popular LBG, focusing on other games as well supports the generalizability of the observations and findings. Viewpoints from other games can further serve to confirm or contrast the findings.

depending on the participant. The authors either took notes during the interviews or recorded them and later transcribed the recordings for analysis. The amount of notes totalled on average 500 words per interview. Due to restrictions brought by the COVID-19 pandemic, we expanded the interviews in August 2020 to an online format. At this stage, we opted for an asynchronous online survey form to support the interviews. This online data collection garnered 62 full responses.

The participants' demographic information across both data collection instances is displayed in Table 2. We consider the sample to be representative of the active LBG players in Finland, but the self-selection bias should still not be overlooked. We gained the most participants from WDOW, followed by Pokémon GO, Orna and HPWU. We asked participants to reply as representatives of the primary game they played. However, more than half of the players reported playing multiple LBGs. This can be considered a strength, as the participants could have viewpoints beyond those specific to an individual LBG. All participants were living in Finland at the time of the interviews and the survey.

On average, the face to face interviews produced three times as much material compared to the online survey. However, in asynchronous data collection, participants have time to carefully conceptualize and craft their responses. Upon preliminary data investigation and interview transcription, the authors scanned the interview and survey data for any notable differences. The interview material was generally richer, but otherwise the responses were similar across both datasets. This is likely due to the questions being the same, albeit that the online survey lacked the follow-up questions presented in the interviews. Based on this analysis, there was no need to analyse the two datasets independently. Accordingly, the online (n = 62) and face to face interviews (n = 12) were combined for analysis as a single data set (N = 74).

3.3. Data analysis

The data analysis consisted of three phases: (1) familiarization with the data; (2) formation of thematic clusters (Guest et al., 2011); and (3) qualitative coding of the raw data (Strauss and Corbin, 1998). In the first step, the authors shared their notes of the face-to-face interviews with one another, and had discussions relating to the overall trends in the interviews to familiarize themselves with the material. Information related to the research questions was already sorted due to the interview structure, but some cleaning of the data was done with the interview data. At this stage, any information completely unrelated to the research questions was discarded.

In the second step, we proceeded to identify and elucidate central themes that arose during participants' responses related to the two main themes and research questions of the study. These arose naturally from clustering the data based on the topic it concerned, but some minor iteration was done on the clusters between the first two authors until the thematic framework adequately described the data (Guest et al., 2011).

In the third step, the coding process, participants' viewpoints were placed into preliminary categories by the author coding the data. During this stage we also picked up interesting or particularly well-formulated quotes from the participants. All participants were interviewed in Finnish, meaning the authors translated the quotes from Finnish to English. While two researchers formulated the thematic framework, only a single researcher carried out the coding. This was not seen as a problem in our case, as our focus was on finding out 'what is' through discovering ideas and issues, instead of quantitative confirmation of the frequency of the themes (Morse, 2007). However, for a few key questions with straightforward and unambiguous responses we also counted the responses for all four games. The results are displayed in Table 3. We discuss the findings of Table 3 and the thematic analysis in depth in the next section.

4. Findings

4.1. AR through the mobile device camera was irrelevant to most players

From the LBGs whose players we interviewed, only Orna was missing an AR-mode. With players from all other games, we asked whether the players used the camera based AR-mode. An overwhelming majority of players (93% across all three games) reported to rarely or never use AR-features. In games such as Pokémon GO where players were at times encouraged to use the AR-features by other game mechanics, for example, when feeding candy to the buddy Pokémon, players stated that in these situations the AR-mode was more of a gimmick than an interesting game mechanic.

"I don't think the AR -mode brings any added value [to Pokémon GO]"

Some participants reported sometimes taking pictures of rare Pokémon using the AR-mode. For example, one respondent said:

Table 2
Demographic information of participants.

Age	**Gender**
18–29 n = 6	Male n = 43
30–49 n = 61	Female n = 30
Over 50 n = 7	Other n = 1
Education	**Primary game**
Primary education n = 1	Harry Potter: Wizards Unite n = 12
Secondary education n = 22	Orna n = 13
Bachelor n = 31	Pokémon GO n = 18
Master n = 19	Walking Dead: Our World n = 31
PhD n = 1	Overall N = 74

Table 3
Depicting numerical information of players' responses to key questions. Note that while the numbers provide insight into how players' perceived the phenomena, they should not be viewed as statistically significant evidence.

	Pokémon GO	HPWU	Orna	WDOW	Cumulative
Players regularly use AR features based on the mobile device camera.	2/18 (11%)	0/12 (0%)	N/A	2/31 (6%)	4/61 (7%)
Players imagine in-game content in the physical world.	5/18 (28%)	3/12 (25%)	1/13 (8%)	2/31 (6%)	11/74 (15%)
Players want in-game PoIs to be linked with physical world objects.	16/18 (89%)	8/12 (67%)	5/13 (38%)	4/31 (13%)	33/74 (45%)
Players want different PoI criteria for urban and rural areas.	6/18 (34%)	7/12 (58%)	N/A	4/31 (13%)	17/74 (23%)
Players want the LBG to fuse with the physical world.	2/18 (11%)	4/12 (34%)	1/13 (8%)	8/31 (26%)	14/74 (19%)

"I take a lot of pictures when I complete research tasks, and if I encounter a new shiny Pokémon I might take pictures of it."

One of the explanations for these findings comes from Alha et al., (2019) who found progression to be a major reason for players to play LBGs. As the AR-mode takes considerable time, players prefer to play the game without it. This was brought up by participants in all three games with AR features. Participants further expressed that even if they used AR features at the beginning of their playing career, they no longer did so. One participant explained as follows.

"I used the AR mode first, but as it is slower to use I prefer not to."

While the lag of the AR-mode was the primary reason for players to not use it, some also stated that they saw it as pointless or having little value to them personally. Upon asking whether the mode supported their imagination, the overwhelming majority of responses stated the opposite. A recent study showed Pokémon GO players enjoy sharing AR-screenshots on social media (Alavesa and Xu, 2020), but in our sample, only one player reported doing so.

4.2. Players rarely imagined the game content in the real world

Pokémon GO is based on the fictional narrative of what if Pokémon were real, HPWU is based on what if wizards and magic were real and WDOW is based on what if our world had zombies. Orna is the only exception as it is not based on any prior franchise. The approaches in Pokémon GO, HPWU and WDOW follow the game design suggestion of Waern et al., (2009) who argued that to engage players, LBGs need to pretend that the game world is real. However, in our data, the majority (85%) of players surprisingly responded as rarely or never imagining in-game content in the real world. In contrast, players across all games expressed that they imagined virtual content on the map interface of their mobile device instead, which can be seen as a 2D visualization of reality. In general, players accepted the 2D map visualization as the playground in LBGs, but not the 3D real world. However, the lack of 3D visualization of AR content does not mean it is not desirable, as some participants expressed they were looking forward to technology better supporting their imagination. For example, one Pokémon GO player explained as follows:

"I don't imagine pokémon in the real world at the moment, but I am looking forward to technology developing to the point where this would be better supported, for example through 3D glasses or other technology."

Other respondents also mentioned glasses similar to Google Glass as being necessary for a realistic fusion between LBGs and the physical world in a 3D perspective. The usability issues of having to view the world through the mobile device camera was seen as immersion-breaking. When pressing participants about what they were thinking while playing, participants rarely admitted to imagining themselves as zombie hunters, pokémon trainers, or wizards. The story of the games was acknowledged by players, but most commonly players were thinking about specific goals within the game while playing, such as I need to catch 5 more pokémon, or I need to get 1200 more experience points. In our sample, players obtained a sense of meaningfulness from strict rules and the social community, rather than the narrative story world of the games. Some Pokémon GO players said they had imagined pokémon in the real world more at the beginning of their playing career, but over the years, the use of imagination has faded away. They described their feelings as follows:

"Early on in 2016 I used to think of myself more as a Pokémon trainer, and intentionally imagine pokémon here in the real world, but currently I do it very rarely."

Another respondent described their feelings in the following way:

"Sometimes [I imagine pokémon in the real world]. Yes I feel the anime series better supports my imagination [than Pokémon GO]. Also, I think it is easier to imagine pokémon in new places in the real world, than in familiar places."

Based on the findings connected to this theme, the four LBGs observed in this study do not manage to converge the game and the physical world in the way that players would continuously or automatically imagine virtual content in the real world. This finding is in line with Sifonis (2019) who looked at whether LBG players would spontaneously have altered visual perceptions about the game and reality, and found this not to be the case. From another perspective, it can be summarized that the AR-features were unsuccessful at supporting players' imagination in the four LBGs. The play taking place through a 2D map directed players to view the LBG world through the 2D map, instead of in 3D. The two dimensional bird's eye view conceptualization of the game world therefore created a disconnect between the game and the physical world. Comparing our findings with previous literature, Jensen et al., (2019) viewed LBGs as layers of reality which can be accessed at will. But in the eyes of LBG players, these appear two dimensional and clearly distinguishable from reality.

4.3. Linking virtual PoIs to real world locations is a double edged sword

Substantial differences were observed between the players on whether virtual PoIs should be linked to real world places in LBGs. These differences may be explained by two trends. First, players living or playing in areas with fewer PoIs reported that they would enjoy it if there were more "places to play" in their neighbourhood. Unsurprisingly, in games where players are driven by a desire to progress (Alha et al., 2019), having enough playing locations was seen as important. In contrast, players living near cultural hotspots with several PoIs argued that it is essential that virtual PoIs are linked to real world objects. Second, players of the Niantic games Pokémon GO (89%) and HPWU (67%) generally favoured having virtual PoIs linked to real world places, whereas players of games with algorithmically generated PoIs, Orna (38%) and WDOW (13%), enjoyed the fact that the game could also be played in rural areas. However, there were some individual differences. For example, one Pokémon GO player stated:

> *"I think generally yes [they should be linked], but it is a bit problematic that rural areas have so few places to play. The Niantic Wayfarer system is also currently not working well and my submissions are getting jammed, so obviously the current system does not work either."*

The player in question clearly had the opportunity to travel to the city where there were more playing locations, but this was not an option for all the players. Many also saw a trade-off between linking PoIs to real world places. The arguments for the linkage were (1) they encourage socializing by directing players to the same areas; (2) they teach players about their local surroundings; (3) they are safer. The arguments given against the linkage were mostly concerned with the lack of PoIs in certain areas such as sub-urban and rural areas. The positive and negative aspects of connecting PoIs to real world places that arose in the data are summarized in Table 4. One participant (a Pokémon GO player) arguing for linking the virtual PoIs to real world locations explained:

> *"The accurate connection of real world places and stops and gyms are part of the game. You learn new things and get to know places. It's especially useful if you're travelling."*

Most players expressed in some way or other that they felt linking PoIs to real world places would increase a sense of immersion while playing. To support the connection between PoIs and real world places, participants suggested, for example, to name in-game areas based on their real world location (e.g. Central Park in New York) but stated that a more specific connection to the real world (e.g. some statue being identified as a PoI) was unnecessary. The least support for making virtual PoIs match real world objects was among WDOW players, of whom only 13% felt a connection to real world places would increase the value of playing. While not statistically significant, this finding gives preliminary evidence towards game mechanics playing a major part in the level of convergence between the real and augmented content that players wish to see. This is further supported by the viewpoints of Pokémon GO and HPWU players, of whom the overwhelming majority (87%) enjoyed or mostly enjoyed the connection of virtual PoIs to the real world. Alternatively and simultaneously, however, PoI coverage in the players' area may be one of the factors that determines which LBG (if any) players end up playing.

4.4. PoI interaction radius needs to be large enough to allow seamless walking while playing

The PoI interaction radius can be defined as the physical distance from which the player can interact with a specific PoI. Depending on the game it can be 10 m or 15 m. The general consensus between respondents with regards to the PoI interaction radius was that it needs to be small enough to motivate travel to places as well as walking, but large enough to avoid the requirement to move right next to a PoI, which could hinder the flow of the playing experience. A recent study on Pokémon GO players, for example, reported that players overwhelmingly appreciated the increased PoI interaction radius that was implemented in the game due to COVID-19 (Laato et al., 2020). In the present study, the small interaction radius was perceived problematic only in HPWU and Pokémon GO where PoIs correspond to real world locations. The reasons given were that occasionally PoIs were situated in inaccessible areas and for some, the GPS signal was not accurate enough for playing with precise PoIs. One participant explained as follows:

> *"A large interaction radius allows me to play while walking in a straight line, and I don't have to keep intruding on private residential playgrounds all the time. But I understand that to keep the game location-based the radius cannot be hundreds of meters."*

This quote exemplifies the participants' diverse opinions on the positive and negative aspects of small and large PoI interaction radii. However, a few of the interviewed players went further to suggest that it is a good idea to create multiple game mechanics regarding PoI interaction. One participant, for example, came up with the following suggestions:

Table 4
The costs and benefits of linking PoIs to real world locations or objects in LBGs.

Primary Stakeholder	Benefits	Costs
Players	Enables players to learn about their local environment while playing.	Will cause an uneven distribution of PoIs, which depending on selected criteria for accepting PoIs, can end up discriminating against specific groups of players.
Players	Players perceive in-game PoIs as more meaningful when they have historical or cultural value, a unique name, pictures, and a backstory. Can motivate players to play the game.	Will direct player movement to places with PoIs, and away from optimal work routes and potentially beautiful scenery.
Developers	Provides the developer with better control over PoIs. Helps ensure legal compliance i.e. that unsafe, illegally placed and harmful PoIs are removed.	Major monetary and practical costs of creating and maintaining such a database.

"Basic mechanics [playing while moving] should have a large interaction radius − 30 m + or so. But raids [in Pokémon GO] where players hang together for a longer time can have a smaller interaction radius"

Thus, while some forms of playing (exercise, moving to a specific location) benefit from a large interaction radius, other forms (socializing, getting to know the local environment) benefit from a small interaction radius. In practise, this can be implemented by ensuring that game mechanics that require movement, have a large PoI interaction radius, and game mechanics that require stationary social play have a small interaction radius.

4.5. Participants did not wish for a higher level of convergence between the game and the real world

Regarding the convergence between LBGs and the physical world, several closely related and overlapping concepts emerged in the data, including entanglement, fusion, connection, linkage and intertwinement of the two worlds. Surprisingly, the majority of all players stated that they did not wish for any stronger convergence between the real and the augmented than what was already implemented in the LBGs, as seen in Table 3. Players felt satisfied with the game in question being placed on real maps, and the avatar location being matched with their physical location. Among HPWU players, 34% desired a higher level of convergence between the real and the augmented, which was the most out of all the four games. For example, one HPWU player who was positive about increasing the connection between the game and reality explained their thoughts as follows:

"Yes [I would wish for a more intense level of connection]. The places we visit should be introduced with some real world game related objects so that instead of seeing the place only in the game we would actually find something cool there."

Only 8% of Orna players wanted a more accurate fusion between the physical world and the game. The reasons given were that it would not add any value to the game, and that not all games have to be like Pokémon GO. One participant reflected on the matter as follows:

"Some games can and others don't have to. There are many stones left unturned in AR-games and I am sure developers should continue experimenting. But not everyone needs to go with as realistic and cinematic a design as possible. I think gameplay is more important."

While the Pokémon GO players in our study were generally satisfied with the connection between the game and the real world (only 11% wishing for a higher level of convergence), two respondents felt there were missed opportunities in linking the LBG with the real world. Participants mentioned that while in the main series Pokémon games such as Red and Blue pokémon creatures appear based on the area they belong to (e.g. water pokémon live near bodies of water and grass type pokémon can be found near grass), this was not well implemented in Pokémon GO. One participant explained as follows:

"If I go to an industrial area I want to find poison pokémon or if I go to a forest I want to find grass and bug pokémon. Now [the developer] just switches which pokémon are available and no such immersion exists. I no longer need to travel anywhere to find a rare pokémon. I just wait for [the developer] to bring it to me."

5. Discussion

5.1. Theoretical and practical implications

Our findings contribute to the research on playful approaches to urban space by focusing on the importance of the playing locations and imagination. While a significant body of academic literature and industry attention has been directed on AR-features working through a mobile device's camera (Diegmann et al., 2015; Rauschnabel, 2021; Yung and Khoo-Lattimore, 2019), we show that in contemporary LBGs these were not valued or appreciated by our sample of players. One of the reasons for this was that AR-features were perceived to be slow and they disturbed rather than helped progression, which has been identified as one of the main reasons for players to play games like Pokémon GO (Alha et al., 2019). The desire to progress in the game also influenced players' attitudes towards in-game PoIs. While a connection between PoIs and real world objects was generally appreciated, players who lived in areas with only a few PoIs wished there were more of them. With these findings, we extend the work of Alha et al., (2019) who showed that progression was the main reason for LBG players to continue playing. The connection between PoIs and the real world has in the worst cases led to cartographic vandalism (Juhász et al., 2020) and to players abusing the Niantic crowdsourcing platform through which in-game PoIs are created. Thus, disentangling PoI creation from the desire to progress, where players see quantity as more important than quality, is a promising avenue to explore as a solution to these issues.

Regarding linking PoIs with real world places, both benefits and costs were identified (as displayed in Table 4). While PoIs can be regarded as the backbone of LBGs (Laato et al., 2019; Söbke et al., 2019; Tregel et al., 2017), the importance of PoI interaction radii and overall game mechanics were highlighted in our findings. For example, the benefit of linking PoIs to real world locations seemed to be less relevant in HPWU where territorial conflict and control of PoIs was not implemented through the game mechanics. Orna players did not wish the controllable areas in the game to be linked to specific locations and preferred the larger areas currently implemented in the game. Some players suggested having different PoI criteria in rural and urban areas to fix the issue of geographical dicrimination (see Juhász and Hochmair, 2017; Tregel et al., 2017). Previous work has shown that PoI locations coupled with a game design that emphasises fast progression and enables playing while driving can lead to a statistically observable population-level increase in traffic accidents (Faccio and McConnell, 2020). Thus, while linking virtual PoIs to real world objects has several benefits, developers need to be careful in their game design to avoid negative real world outcomes.

Ultimately, by answering the two RQs posed in this study we contribute to (1) the understanding of the role of PoIs in player

experience in LBGs; and (2) other ways LBGs can connect the game world to the physical world such as through AR-features. Our findings indicate that among the options LBG developers have for scaffolding a connection between reality and the game world, the game map corresponding to the real world is important. In practice this means that roads and buildings on the game map interface should correspond to roads and buildings in the physical world. As the player moves around in the real world, their avatar follows in the game world. In contrast, AR-features which superimpose digital content on top of the real world through the mobile devices' camera were not seen to be equally important. Thus, regarding AR features, multimodal possibilities of implementing AR that go beyond mobile device camera technology are needed (Rauschnabel, 2021). Finally, upon exploring the role of imagination while playing, we found AR-features to be unhelpful in creating an illusion of the game world being real. The overall theoretical implications of this study are summarized in Table 5.

5.2. Implications for location-based game design

Our study has implications on LBG design which deserve to be discussed separately from the theoretical and practical implications. Here we summarize three design implications arising from the thematic analysis, which we feel are relevant to LBG designers for creating more engaging and enjoyable playing experiences.

Design implication 1: motivating the use of AR-features. To better motivate players to use AR-features, LBG designers should try to make it equally fast or even faster to use AR rather than to not use it. Especially when progression is the primary motivation for continuing to play (Alha et al., 2019), the slowness of AR features is a major inhibitor for players to use them.

Design implication 2: optimal PoI interaction radius. Playing that is done by moving, and related game mechanics, should have a large interaction radius to enable smooth travelling while playing. However, game mechanics where players are in the same place for a longer time period should have a shorter interaction radius, in order to enable players to socialize and learn about the real world PoI that they are located in.

Design implication 3: attention to PoI criteria Rural players wished for loose PoI criteria or some other means to obtain more playing locations where they lived. Following Tregel et al., (2017) LBG designers should look into creating virtual PoIs that are connected to real world objects, but find remedies to compensate players who live in areas with little to no significant real world objects.

5.3. Limitations

Due to the difficulty of recruiting and reserving players for interviews during the COVID-19 pandemic, we only interviewed 12 players face to face while the rest responded to the same questions asynchronously online. The richness of the responses in the face-to-face interviews was higher, but as the themes in both data collection approaches were similar, we did not consider this to be a problem in our data. The limitations regarding participant sampling also need to be discussed. We contacted group moderators in the player communities that were familiar to us. One such community had little gender diversity (Orna, where all participants were male), which can be either due to the game being attractive to a male-only audience or a bias in our sampling. In the case of other games, no such bias was identified. However, the representativeness of the sample may still be called into question due to it being sourced from a culturally

Table 5
The main theoretical contributions of this study.

Previous findings	What this study adds
Players share screenshots and AR-photos of their playing on social media, which further blends LBGs to reality (Alavesa and Xu, 2020).	The sharing of achievements is generally much more important for players than the photos. The AR-mode can at times be used to impress other players, but only a few regularly use it.
LBGs should aim to scaffold the make-believe of 'what if the game was real' to engage players (Waern et al., 2009)	Progression was a major motivation for players to play, and too accurate a fusion with the physical world was at times in conflict with this goal as it slowed down progression.
PoI placement can dictate which geographical areas LBG players perceive as meaningful and where they play (Colley et al., 2017; Papangelis et al., 2020)	The connection of PoIs to the real world increased players' perceptions of the meaningfulness of the location. In general for players motivated by progression, the quantity of PoIs was more important than their quality.
Linking PoIs to real world locations enables players to learn about their surroundings while playing (Oleksy and Wnuk, 2017)	Players appreciated a small interaction radius with PoIs and a connection to the real world in particular in three cases: (1) when players get together at a specific place for a longer period of time to play; (2) where players want to learn about their local environment; or (3) where they are required to socialize with other players.
Linking PoIs to real world locations enables safer playing (Laato et al., 2019)	PoIs linked to real world locations can also be more dangerous in cases where they are coupled with a shorter interaction radius, demanding players to go to extremely close proximity to the PoI.
When connecting PoIs to real world locations rural areas and areas inhabited by minorities end up having less PoIs, making playing less fun and optimal (Juhász and Hochmair, 2017)	Players gravitate to specific LBGs based on how many PoIs their living areas have in those games.
An uneven distribution of PoIs and having a poor playing environment can in worst cases motivate players to destructively modify existing map services such as OpenStreetMaps (Juhász et al., 2020)	As popular LBG players are motivated by progression and a larger quantity of PoIs enable faster progression, players are incentivized in worst case scenarios to even vandalize Niantic's crowdsourced PoI database or OpenStreetMaps.

heterogeneous area.

Our study also has limitations with regards to data analysis. We conducted a thematic analysis on the respondents' replies regarding connecting LBGs to the real world. We focused in particular on material related to the two research questions of the study. This was made easier by the employed structured survey format (see Appendices 1-4), where responses were already connected to higher level topics. However, due to author bias, some information or viewpoints may still have been omitted or misinterpreted in the data. As a remedy, we attempted to mitigate such issues by familiarizing ourselves with the data prior to the analysis. The initial thematic framework was created and iterated by the same authors who interviewed the participants. Inevitably, some researcher interpretation was present during the interviews, and also in the data analysis and construction of the thematic framework. Only a single author coded the participants' responses, and some selection bias could also have been present in the selection of the presented quotes from participants in Section 4. Finally, the data was cross-sectional, meaning the status quo regarding the identified themes may have changed over time. For example, AR features may have been more relevant for players during the beginning of their career, but not later on. As we surveyed primarily experienced players, this may show in our results. However overall, given the continuity of themes within the data and the correspondence of our findings with external literature, we assume that any inherent bias had no meaningful effect on the research outcomes.

6. Conclusions and future work

In this study we qualitatively investigated the convergence between LBGs and the physical world. To this end, we conducted semi-structured face-to-face interviews (n = 12) and repeated the survey online (n = 62) to players across four LBGs. One of the surprising findings was that only a small number of participants (7%) regularly used or enjoyed the AR-features of the LBGs. The most common reasons for this were that: (1) they slow down playing and consequently progression; and (2) they are unrealistic and do not provide value to players. A few participants exclusively mentioned that AR could work better through smart glasses, which is a promising future direction to explore with regards to 3D AR in LBGs. Generally, the surveyed players also expressed a wish that the game and real world would be distinguished from one another, and only 19% wanted a higher level of convergence between the game and the real world. However, there were substantial differences in this regard between games, which warrants further research on the topic.

Our findings also revealed three design considerations for LBGs. The first was related to AR-features working through the mobile devices' camera. While players expressed AR features to be at times unrealistic and to provide a little additional value, the main reason players in our sample stated they did not use them was their slowness. The second design consideration was about the potential to vary the PoI interaction radius depending on whether playing occurs while moving (large radius) or when standing still (small interaction radius). Future experimental work could examine whether different interaction radii leads to confusing playing experience, or whether it works as suggested in the interviews. The third and final design recommendation was about the criteria by which LBGs select virtual PoIs in their game. Here, based on previous work (Laato et al., 2019; Tregel et al., 2017) and the current empirical study, LBG designers should integrate virtual PoIs with real world objects, but they need to look for ways to compensate rural players for the lack of static real world PoIs in their area. We therefore encourage LBG designers to consider these changes, in order to create more engaging and meaningful playing experiences for their players.

In summary, the convergence between LBGs and the physical world contains various aspects and trade-offs, and it is by no means clear that LBG design should aim for as high a level of connection between the augmented and the real as possible. We also found evidence of individual differences in desires and preferences regarding LBG design, related to connecting the game with reality. Connecting the virtual PoIs of LBGs to the real world can have the benefits of (1) facilitating social meetings; (2) teaching about the real world; and (3) increasing the meaningfulness of playing. But this can also replicate geographical imbalances by discriminating against rural areas and poor areas and by extention, the players in them (Juhász and Hochmair, 2017). While AR features using the mobile devices' camera were not widely used by players, the surveyed players expressed hopes that future technological advances could rekindle their interests in the technology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This article was supported by the Academy of Finland Flagship Programme under Grant No. 337653 (Forest-Human-Machine Interplay (UNITE))

Appendix 1. The core set of questions for Pokémon GO players

Background questions: Research permission, demographic information and playing experience.

(*continued on next page*)

(*continued*)

Part 1. AR, story and imagination:

(1) Do you use the AR features in-game? Why/why not? How could they be improved?
(2) What goes on in your mind while playing? What specific game-related thoughts do you have?
(3) Do you ever imagine pokémon here in the real world? In what kinds of situations do you do so?
(4) Do you have prior experiences with the Pokémon franchise? Tell us about these experiences.
(5) What makes Pokémon GO interesting to you?
(6) How meaningful is social interaction with other players to you? Why/why not?
(7) Do you feel collecting Pokémon and achievements is a meaningful activity? Why/why not?
(8) Does the story and imagination while playing make the playing experience feel more meaningful to you? Why/why not?

Part 2. Points of interest and the playing locations:

(1) Do you care whether stops and gyms (the virtual PoIs) correspond to real world objects? Why/why not?
(2) Should urban and rural areas have different criteria for PoIs? What advantages do you see in doing this? What is your personal preference? Why?
(3) Do you feel the connection between the virtual PoIs and real world objects increases the meaningfulness of playing? What about immersion? Do you feel they make playing feel more real?
(4) Should LBGs similar to Pokémon GO aim to fuse with the real world? Why/why not? Do you personally wish Pokémon GO to be more entangled with reality?
(5) How do you feel about the interaction radius to PoIs? Should the doubled interaction radius that was introduced to Pokémon GO during COVID-19 be made permanent? Why?

Appendix 2. The core set of questions for Harry Potter: Wizards Unite players

Background questions: (–)
Part 1. AR, story and imagination:

(1) Do you use the AR features in-game? Why/why not? How could they be improved?
(2) What goes on in your mind while playing HPWU? What specific game-related thoughts do you have?
(3) Do you ever imagine game content such as fortresses, green houses, inns or traces here in the real world?
(4) Have you read the Harry Potter books, watched the movies or played other Harry Potter -themed games?
(5) What do you find interesting or meaningful in HPWU?

Part 2. Points of interest and the playing locations:

(1) Do you care whether the inns, fortresses and greenhouses correspond to objects or buildings in the real world?
(2) Does the connection between real world objects and inns, fortresses and greenhouses increase the immersiveness of the game or a sense that the game is part of the real world?
(3) Should LBGs such as HPWU aim to integrate with the real world as strongly as possible?
(4) Should rural areas have different PoI criteria than urban areas? Why/ why not?

Appendix 3. The core set of questions for Orna players

Background questions: (–)
Part 1. AR, story and imagination:

(1) Do you wish for more realistic graphics for Orna? Why/ why not?
(2) Would you like the game to have an AR mode that works through the mobile device's camera?
(3) When playing Orna, how do you perceive the world around you and do you care where you play?
(4) Do you ever imagine Orna's buildings or creatures in the real world?
(5) Do you have experience from other games similar to Orna? Which ones? How do they differ?
(6) What do you find meaningful or engaging in Orna?

Part 2. Points of interest and the playing locations:

(1) Should dungeons and other buildings in Orna correspond to objects in the real world? Why/why not?
(2) Do the fixed dungeon locations increase a sense of immersiveness of playing or a sense that the game is part of the real world?
(3) Should games such as Orna aim for as fastidious fusion between the real world and the game as possible?

(*continued on next page*)

(*continued*)

(4) Do you feel that a connection between real world objects and objects in the game world would open up new game design opportunities for Orna?
(5) Should the changes introduced during the COVID-19 pandemic such as the boost "It's still dangerous out there" be made permanent?

Appendix 4. The core set of questions for the Walking Dead: Our World players

Background questions: (–)
Part 1. AR, story and imagination:
(1) Do you use the AR features that work through the mobile device's camera? Why? Why not?
(2) What are you generally thinking when playing WDOW?
(3) Do you view and imagine the game through the map interface or otherwise?
(4) Do you ever imagine zombies here in the real world?
(5) Have you watched the Walking Dead series or played other games based on the franchise?
(6) What do you find meaningful or interesting in WDOW?
Part 2. Points of interest and the playing locations:
(1) Do you care whether infestations, encounters and rescue missions are connected to objects in the real world or not?
(2) Should games such as WDOW aim for as fastidious fusion between the game and the real world as possible?
(3) Should central cultural locations and hotspots have more playing locations than other areas? Why/why not?
(4) Should the added features implemented during COVID-19 to compensate for lockdowns be left in the game?

References

Alavesa, P., Xu, Y., 2020. Unblurring the boundary between daily life and gameplay in location-based mobile games, visual online ethnography on Pokémon GO. Behav. Inform. Technol. 1–13.

Alha, K., Koskinen, E., Paavilainen, J., Hamari, J., 2019. Why do people play location-based augmented reality games: A study on Pokémon GO. Comput. Hum. Behav. 93, 114–122.

Althoff, T., White, R.W., Horvitz, E., 2016. Influence of Pokémon Go on physical activity: study and implications. J. Med. Internet Res. 18 (12), e315. https://doi.org/10.2196/jmir.6759.

Bhattacharya, A., Windleharth, T.W., Ishii, R.A., Acevedo, I.M., Aragon, C.R., Kientz, J.A., Lee, J.H., 2019. Group interactions in location-based gaming: A case study of raiding in pokémon go. In: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, pp. 1–12.

Chapple, Craig, (2020) Pokémon GO Surpasses $3.6 Billion in Lifetime Revenue as It Celebrates Four-Year Launch Anniversary, [ONLINE], available at: https://sensortower.com/blog/pokemon-go-revenue-year-four, accessed 26th of September, 2020.

Colley, A., Thebault-Spieker, J., Lin, A.Y., Degraen, D., Fischman, B., Häkkilä, J., Wenig, D., 2017. The geography of Pokémon GO: beneficial and problematic effects on places and movement. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, pp. 1179–1192.

Coombes, L., Allen, D., Humphrey, D., Neale, J., 2009. In-depth interviews. Research Methods Health Social Care 197–210.

Diegmann, P., Schmidt-Kraepelin, M., Eynden, S., Basten, D., 2015. Benefits of augmented reality in educational environments-a systematic literature review. Benefits 3 (6), 1542–1556.

Dirin, A., Laine, T.H., 2018. User experience in mobile augmented reality: emotions, challenges, opportunities and best practices. Computers 7 (2), 33.

Faccio, M., McConnell, J.J., 2020. Death by Pokémon GO: The economic and human cost of using apps while driving. J. Risk Insurance 87 (3), 815–849.

Fonseca, X., Lukosch, S., Brazier, F., 2020. Secrets of the south: A location-based game for the development of 21st century social skills and promotion of social interaction. CEUR Workshop Proceedings. CEUR-WS.

Guest, G., MacQueen, K.M., Namey, E.E., 2011. Applied thematic analysis. SAGE Publications Inc.

Hamari, J., Malik, A., Koski, J., Johri, A., 2018. Uses and gratifications of pokémon go: Why do people play mobile location-based augmented reality games? Int. J. Human-Computer Interaction 35 (9), 804–819.

Hino, K., Asami, Y., Lee, J.S., 2019. Step counts of middle-aged and elderly adults for 10 months before and after the release of Pokémon GO in Yokohama, Japan. J. Medical Internet Res. 21 (2), e10724. https://doi.org/10.2196/10724.

Irshad, S., Rambli, D.R.B.A., 2014. User experience of mobile augmented reality: A review of studies. In: 2014 3rd International Conference on User Science and Engineering (i-USEr). IEEE, pp. 125–130.

Jensen, L.J., Valentine, K.D., Case, J.P., 2019. Accessing the pokélayer: Augmented reality and fantastical play in Pokémon Go. In: Educational Media and Technology Yearbook. Springer, Cham, pp. 87–103.

Juhász, L., Hochmair, H.H., 2017. Where to catch 'em all?–a geographic analysis of Pokémon Go locations. Geo-spatial Inform. Sci. 20 (3), 241–251.

Juhász, L., Novack, T., Hochmair, H.H., Qiao, S., 2020. Cartographic Vandalism in the Era of Location-Based Games—The Case of OpenStreetMap and Pokémon GO. ISPRS Int. J. Geo-Inf. 9 (4), 197.

Khamzina, M., Parab, K.V., An, R., Bullard, T., Grigsby-Toussaint, D.S., 2020. Impact of Pokemon Go on physical activity: a systematic review and meta-analysis. Am. J. Prev. Med. 58 (2), 270–282.

Laato, S., Pietarinen, T., Rauti, S., Laine, T.H., 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, pp. 153–160.

Laato, S., Islam, A.K.M.N., Laine, T.H., 2020. Did location-based games motivate players to socialize during COVID-19? Telematics Inform. 54, 101458. https://doi.org/10.1016/j.tele.2020.101458.

Lee, J.E., Zeng, N., Oh, Y., Lee, D., Gao, Z., 2021. Effects of Pokémon GO on Physical Activity and Psychological and Social Outcomes: A Systematic Review. J. Clinical Med. 10 (9), 1860.

Leorke, D., 2018. Location-based gaming: play in public space. Palgrave Macmillan, Singapore.

Mozelius, P., Eriksson Bergström, S., Jaldemark, J., 2017. Learning by Walking-Pokémon Go and Mobile Technology in Formal Education. In: 10th International Conference of Education, Research and Innovation, Seville, Spain, NOV 16-18, 2017. The International Academy of Technology, Education and Development, pp. 1172–1179.

Morse, J. M. (2007). Qualitative researchers don't count. Qualitative Health Research. 17(3).

Mozelius, P., Jaldemark, J., Bergström, S.E., Sundgren, M., 2019. Augmented education: location-based games for real-world teaching and learning sessions. In: Augmented Reality Games I. Springer, Cham, pp. 217–235.

Nairne, J.S., Pandeirada, J.N.S., Gregory, K.J., Van Arsdall, J.E., 2009. Adaptive memory: Fitness relevance and the hunter-gatherer mind. Psychol. Sci. 20 (6), 740–746.

Oleksy, T., Wnuk, A., 2017. Catch them all and increase your place attachment! The role of location-based augmented reality games in changing people-place relations. Comput. Hum. Behav. 76, 3–8.

Papangelis, K., Metzger, M., Sheng, Y., Liang, H.-N., Chamberlain, A., Cao, T., 2017. Conquering the city: Understanding perceptions of mobility and human territoriality in location-based mobile games. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies 1 (3), 1–24.

Papangelis, K., Chamberlain, A., Lykourentzou, I., Khan, V.-J., Saker, M., Liang, H.-N., Sadien, I., Cao, T., 2020. Performing the Digital Self: Understanding Location-Based Social Networking, Territory, Space, and Identity in the City. ACM Trans. Computer-Human Interaction (TOCHI) 27 (1), 1–26.

Rauschnabel, P. A., Rossmann, A., & tom Dieck, M. C. (2017). An adoption framework for mobile augmented reality games: The case of Pokémon Go. Computers in Human Behavior, 76, 276-286.

Rauschnabel, P.A., 2021. Augmented reality is eating the real-world! The substitution of physical products by holograms. Int. J. Inf. Manage. 57, 102279. https://doi.org/10.1016/j.ijinfomgt.2020.102279.

Remmer, M., Denami, M., Marquet, P., 2017. Why Pokémon GO is the future of school education: effects of AR on intrinsic motivation of children at elementary school. In: Proceedings of the Virtual Reality International Conference-Laval Virtual 2017, pp. 1–5.

Ruiz-Ariza, A., Casuso, R.A., Suarez-Manzano, S., Martínez-López, E.J., 2018. Effect of augmented reality game Pokémon GO on cognitive performance and emotional intelligence in adolescent young. Comput. Educ. 116, 49–63.

Sifonis, C.M., 2019. Examining Game Transfer Phenomena in the hybrid reality game, Ingress. Int. J. Human-Computer Interaction 35 (17), 1557–1568.

Söbke, H., Hauge, J.B., Stefan, I.A., 2017. Prime example Ingress reframing the pervasive game design framework (PGDF). International Journal of Serious Games 4 (2).

Söbke, H., Baalsrud Hauge, J., Stefan, I.A., 2019. Long-term Engagement in Mobile Location-based AR Games. In: Geronimenko, V. (Ed.), Augmented Reality Games I. Springer, Cham, pp. 129–147. https://doi.org/10.1007/978-3-030-15616-9_9.

Strauss, A., Corbin, J., 1998. Basics of qualitative research techniques. Sage publications, Thousand Oaks, CA.

Tregel, T., Raymann, L., Göbel, S., Steinmetz, R., 2017. Geodata classification for automatic content creation in location-based games. In: Joint International Conference on Serious Games. Springer, Cham, pp. 212–223.

Waern, A., Montola, M., Stenros, J., 2009. April). The three-sixty illusion: designing for immersion in pervasive games. In: Proceedings of the SIGCHI conference on human factors in computing systems, pp. 1549–1558.

Wolf, M., Wehking, F., Söbke, H., Londong, J., 2020. Location-based Apps in Environmental Engineering Higher Education. Proceedings of DELbA 2020 - Workshop on Designing and Facilitating Educational Location-based Applications.

Yung, R., Khoo-Lattimore, C., 2019. New realities: a systematic literature review on virtual reality and augmented reality in tourism research. Current Issues in Tourism 22 (17), 2056–2081.