Location-Based Games For Social Interaction In Public Space

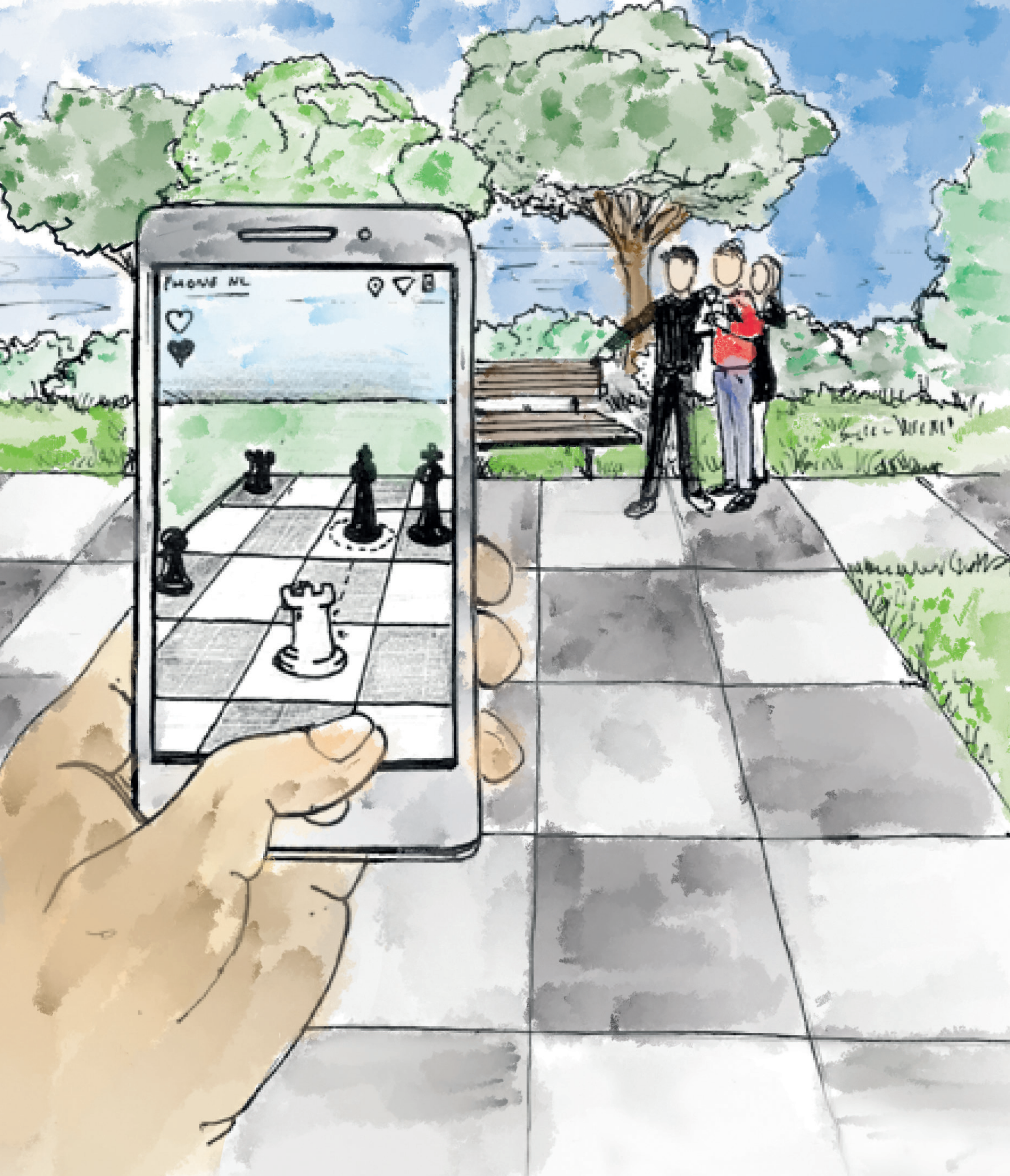
Fonseca, Xavier

DOI
10.4233/uuid:9db1a0c4-89ba-4f9b-b32a-47b7bca5b55e

Publication date
2021

Document Version
Final published version

Citation (APA)
Fonseca, X. (2021). *Location-Based Games For Social Interaction In Public Space*. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:9db1a0c4-89ba-4f9b-b32a-47b7bca5b55e



LOCATION-BASED GAMES FOR SOCIAL INTERACTION IN PUBLIC SPACE

XAVIER FONSECA

Location-based Games for Social Interaction in Public Space

LOCATION-BASED GAMES FOR SOCIAL INTERACTION IN PUBLIC SPACE

Thesis

for the purpose of obtaining the degree of doctor
at Delft University of Technology,
by the authority of the Rector Magnificus prof. dr. ir. T.H.J.J. van der Hagen,
chair of the Board for Doctorates,
to be defended publicly on
Thursday 28th of January 2021 at 12:30 o'clock

by

Francisco Xavier DOS SANTOS FONSECA

Master in Computer and Telecommunications Engineering,
University of Aveiro, Portugal,
born in Vila Nova de Gaia, Porto, Portugal.

This thesis has been approved by the promotors.

Composition of the doctoral Committee:

Rector Magnificus,	chairperson
Prof. dr. F.M. Brazier,	Delft University of Technology, promotor
Prof. dr. S.G. Lukosch,	University of Canterbury, New Zealand, promotor
Prof. dr. D. Helbing,	ETH Zürich, Switzerland, promotor

Independent members:	
Prof. dr. B. Schouten	Eindhoven University of Technology
Prof. dr. M.A. Neerincx	Delft University of Technology
Dr. L. Morgado	Universidade Aberta, Portugal
Dr. V.T. Visch	Delft University of Technology
Prof. dr. C.M. Jonker	Delft University of Technology, reserve member

Cover design by Eduardo Soares.

Keywords: Location-based Games, Serious games, Software Architecture, Gameplay Requirements, Social Interaction, Social Cohesion, Meaningfulness, Public Space.

SIKS Dissertation Series No. 2021-1
The research reported in this thesis has been carried out under the auspices of SIKS, the Dutch Research School for Information and Knowledge Systems.

ISBN 978-94-6421-198-6

An electronic version of this dissertation is available at http://repository.tudelft.nl/.

Tu podes descobrir mais sobre uma pessoa numa hora de brincadeira do que num ano de conversa.

Gleydson

Acknowledgements

Um testemunho de força, resiliência, pura loucura,
e persistência. Uma jornada de batalhas e vitórias
até aos ombros do gigante que é o conhecimento.

Obrigado a vós, todos vós que me quereis bem
e não me vacilais no vosso apoio e presença.

The year I entered TU Delft was a hectic one. I had been looking previously at scholarships for at least half a year, and I knew it was going to be a year of change at all levels. Two months before me being accepted as a PhD candidate at TU Delft, the same had happened at a Marie Skłodowska-Curie Action in Greece/Sweden. I had a one way ticket to Athens already, and was mentally prepared for what that meant when I received an email from TU Delft that changed my life forever. Within the following month I had numerous debates with Prof. Dr. Dirk Helbing, fellow professor friends I have throughout the Portuguese Academia, and my best friend Tiago Gomes. All the professors said the same: "*The Netherlands is a research hub, and I would go there if I were you!*". My best friend joked about it: "*If they pay you more, you go!*". Hahahah... Well, suffice to say, I love the decision I made.

I am profoundly grateful for the experience I had, a journey that taught me the absolute value of collaboration and kindness. The saying "*When we clash, we meet*" could not be truer in this journey, where previous learnings and different cultural norms and values proved to be a raw baggage and a beautiful opportunity to personal growth. Through my endeavour towards the degree of doctor, I made friends for life, had the most enlightening debates and exchanges of perspectives, became a better professional with the best promotion I could ever have, and learned to be a (somewhat) better man. I am richer today, for what I carry in my mind and heart do not fit within any scale of worth. I am entirely grateful for everyone that crossed my path, and, with "open" heart, I 100% subscribe to the words of Antoine:

Those who pass by us, do not go alone, and do not leave us alone;
they leave a bit of themselves behind, and take a little of us with them.

Antoine de Saint-Exupéry

First of all, I would like to express my gratitude to my promotors at TU Delft, Frances Brazier and Stephan Lukosch, for believing in me and setting up an environment of growth and personal development. Frances, I have been blessed with the opportunity of working with you and be exposed to both your constructive critique and your craft for making written content always shorter. It is a delight to witness your magic on e-mails, and a great opportunity to be taught about how difficult it is to come across in the right way. Thank you for being

my mentor and my friend, for the wonderful exchange of experiences and perspectives you have on the world, for your support in difficult times, and for your honest and strong attitude when I needed it. Stephan, thank you for your continuous support, all the while instigating me to think for myself: an absolute requirement for a doctorate degree. You always gave me your opinion straight, rooted in how the world actually works. More than the fact that your opinions proved to be "quite more-than-often" right, I am truly grateful for the wonderful and fruitful debates we had. I am where I am today because of you! Thank you.

I also need to express my utmost respect and gratitude to my promotor at ETH Zurich, Dirk Helbing, for all the support, guidance, unique perspective, and incentive to collaboration. Dirk, you created the very opportunity to do my PhD at TU Delft, and I am forever grateful for the personal and professional growth that you enabled in me. You had a brilliant idea, to bring multiple PhD candidates together to tackle through responsible engineering the wicked problems the world sees today. You helped us work together, invested your energy and helped us come together, and contributed to our success in proposing responsible innovation to the world. I am grateful for the summer retreats you create every year, for it allowed to meet and work together with you and your team at ETH. We bonded, and I have amazing friends at ETH and abroad because of you.

Throughout my PhD I had the opportunity to work closely together with many of you. Heide Lukosch, Simon Tiemersma, Geertje Slingerland, and Olivier Hokke, thank you for the synergy and hard work put in my research project. I learned with you, grew up with your perspectives and by working together with you, and came to develop a deep respect for you and your expertise. Today I am your friend, cherish this friendship, and will hold you close to my heart forever. I am also acknowledging the brave of heart that actively supported my work: Isabelle Kniestedt, Hendrik Engelbrecht, Kusnandar Kusnandar, Bramka Jafino, Amir Fard, Daniel Broca and Anique Kuijpers. Thank you for your help, you contributed to make my work a success.

The journey towards a PhD degree is best done when shared. I am very blessed for the opportunities I had to share both my hardships and victories with Indushree Banerjee, Sergei Zhilin, and Arthur Feinberg. You have gradually become my brothers and sister, for the journey I have done is yours as well. We travelled throughout the world together, shared our differences and learned the craft of tolerance (a lot), cooked together in retreats, whined a lot about democracy 2.0 and benevolent dictators, supported each other's mental resilience, and shared life together. I LOVE you very much, and I consider you my family! Amir, Amit Ashkenazy, Rijk Mercuur, and Farzam Fanitabasi, it is a privilege to be your friend, to have met your home and your family, and to have shared this experience with you.

Throughout this last half a decade I have had the complete privilege to work in a section that welcomed me and made me part of a family. The Systems Engineering section of the Multi-Actor Systems has become part of my home, not only because I often worked until security kicked me out of the building, but because I love all my colleagues, present and past. Marina, Indushree, Kusnandar, Geertje, Isabelle, Michel, Sander, Nina, Martijn, Selma, Rado, Vasiliki, Tina, Stephan, Iulia, Angelo, Hendrik, Vittorio, Yilin, Supriya, Mohammad, Tanja, Evangelos, Chen, Agnes and Esther - Thank you. Marina Cidota, Hendrik and Chen Wang, you could not have been better office mates: it was a pleasure sharing the office with you. This recognition is also extended to the other sections of the faculty, particularly those within the MAS department: thank you for your kindness and everyday joy, I could not have worked in better company.

I am also very grateful for TU Delft and the experience it provided me. Part of my faculty is an initiative called PhD Council, and, through it, I met other lovely people in similar situations, or people that have done their PhD already and supported me just as much. To Fernando, Maria Freese, Tristan, Ioanna, Shahrzad, Aashis, María, Sina, Javanshir, Shantanu, Trivik, and all of you who shared the joys of the PhD life with me. Thank you for being wonderful people.

Outside the professional realm, and while acknowledging the influence that other people had in my PhD journey, I would be remiss in forgetting a special person: Inês. It was a very demanding journey to both of us, day-in day-out, all year round, and your love and kindness helped me go through it. You were there for me, and I will forever remember you as the loving and supportive person you were to me. *Obrigado por tudo, miúda*.

I am also explicitly recognising those who helped me with their educated opinion regarding going to The Netherlands. Dr. João Paulo Barraca, Dr. Diogo Gomes, and Dr. Ricardo Gonçalves, thank you for your wide scientific perspective and for personally helping me in my decision-making process. Tiago Gomes, I would not be where I am today, had it not been for you and your dashing attitude (which I am absolutely in love with). João Barroso - thank you.

I cannot forget how challenging it is to immigrate and adapt to a new country. Every time. To adapt and overcome was required to excel at this PhD position, and key to that was, of course, friendship and meaningful connections. To my friends in The Netherlands, Catarina, Eduardo Soares, Sandro, José Dores, Nicole, Robert, Fabiana, Jolien Strous, Fabiana, Leonor, Diego Lisi, and, especially, Marisa Rocha, Ana Vieira, and Luís Cunha. I am very fortunate to have you as friends, for having had my birthdays with you, for having you making me cry and helping me move forth with my life (while drinking to it). You are utterly responsible for my success and my currently perfect emotional well being. Job well done, lads and lassies.

My family, I am indebted to you for all your unwavering support during these and past years. You are the cornerstone in my emotional resilience, without which everything (this thesis included) would not exist. I love you, and I know having been away from home has been tough to all of us. Everything, every success I collect from life itself, I owe it to you. More than the education you gave me, it is your unconditional love that makes me feel it is OK to stumble, suffer, fight in life, and move forth, for you are ALWAYS there for me. It is a bliss to still have you alive, well, and capable of witnessing my doctoral upbringing. Being an immigrant without you feels like running on borrowed time. Therefore, this thesis is OUR effort, OUR reward. We deserve it.

This thesis is a novel contribution to science, and an important milestone to me, and, hopefully, to all of you who read it. People live in ever-more-polarised societies, and connection is an often neglected intrinsic human need that is tightly linked to mankind's well being. People are lonely because it is easier to build walls instead of bridges, and nothing like playful behaviour to bring people together in joy and pleasurable challenge. Let us contribute to meaningful play, and bring people closer together.

Xavier Fonseca
December 23, 2020

Contents

1

INTRODUCTION

As pessoas são solitárias porque constroem muros ao invés de pontes.

Antoine de Saint-Exupéry

Connection is an intrinsic human need tightly linked to mankind's well-being (Cacioppo and Patrick, 2008). Fostering meaningful social interaction through structured, play-based activities exposes participants to a type of behaviour that fosters the strengthening of the social fabric of its local communities (Fonseca et al., 2018a; Peters et al., 2010; Schouten et al., 2017). Play is a means to foster such interaction. From the perspective of societies, play has fundamental characteristics that have shown to be important to the very development of civilisation (Ehrmann et al., 1968; Rodriguez, 2006). Play takes a crucial role in the foundation and maintenance of cultures, through many social activities and behaviours that shape, and even dictate, the purpose of interaction (Tanghe, 2016) ranging from Arts to Philosophy, and in the etiquettes of law enforcement and warfare (Ehrmann et al., 1968; Huizinga, 1955; Huizinga and Seresia, 1952).

Technology is present everywhere, and given it has gradually been made more accessible to everybody, it is now used by millions of people for the purpose of play. From the use of text-based monochromatic games to novel ways of interacting with technology, the world of play is now possible in ways previously impossible to achieve. Players across the world can now synchronously play together, enable their bodies to act as controllers of the game, and even have such play permeate their daily lives (van Delden, 2017). Play through technology has become so successful, that it even enabled smart and digital cities to become 'playable'. Sensors and actuators have enabled players to enter the world of play, interact with it and with those around them, and have allowed for factors such as location and social context to be included in the gameplay experience (Couch, 2017). Ludic social behaviour has been enabled through important factors such as audio-visual media, perfected telecommunications, and ubiquitous internet (Nieuwenhuys, 1974). Elements from architecture to psychological elements affecting behaviour and communication, bring novel ways of play traditionally not experienced by players, and invite them to engage with their city and other citizens (Innocent, 2020). Play-based activities, throughout smart urban environments, propose a positive way of using technology already available to citizens to create stronger and healthier communities, as they bring inhabitants together in a joyful way (De Lange, 2015; Hassan and Thibault, 2020; Stevens, 2007).

Location-based games (LBGs) embrace a relatively new type of gameplay (since early 2000's) that blends digital fictitious game worlds with the real environment of players: combining technology capable of locating players in space and interpret/use their real-world context to enhance the gaming experience (Avouris and Yiannoutsou, 2012). LBGs expand the fictitious boundaries of play that traditional games offer, with an ubiquitous outdoor play experience that embraces different outdoor locations (with GPS coverage) and contexts (dependent on the availability of network service) (Mullen, 2013), and interaction with others. Such games invite players to actively engage and interact with both their surroundings and everything and everyone they contain (Rashid et al., 2006). Such fun-based social experiences and exchanges have potential use beyond pure entertainment (Clark and Clark, 2016; Flintham et al., 2007; Fonseca, Lukosch, Lukosch, and Brazier, 2020; Hodson, 2012; Korhonen et al., 2008; Papangelis et al., 2017; Peitz et al., 2007; Pyae et al., 2017; Sotamaa, 2002). LBGs such as Pokémon Go, for example, have become so successful that cities have explored their use for serious purposes such as boosting civic engagement in local communities, often with the order of thousands of people (B. Stokes et al., 2018). Using LBGs for the promotion of meaningful social interaction is the challenge this thesis addresses.

On the one hand, meaningful interactions are person-dependent (Putnam, 1975): what is meaningful to a user may not be so to another. Social interaction in itself can occur in multiple ways (Bardis, 1979), and this mandates understanding of users' preferences, needs and desires for their own interactions with their fellow neighbours, which likely vary throughout neighbourhoods and age groups. In addition to users' preferences with respect to the way they prefer to interact, specific knowledge on how social interaction is associated to the upkeep of a cohesive and resilient social fabric in communities is of importance. Social cohesion is key to social resilience, but cohesion is a construct for which there is not one universal definition or sets of tools and methods with which it can be measured (Friedkin, 2004; Pahl, 1991). Social cohesion is complex social construct due to the fact that different societies have different geographies, political representations, economics, and problems (Bruhn, 2009). On the one hand, fostering social cohesion in cities means creating societies where people have the opportunity to live together with all their differences, and, on the other hand, the way to approach unity and diversity, and the thresholds involved, is unknown to specialists (Novy et al., 2012). This means that there is a gap in current understanding of social resilience and its social dimensions, which must be addressed to design interventions aiming for more sustainable resilient systems.

On the other hand, although the potential of location-based games to promote meaningful social interaction[1] (Straker et al., 2014) has been recognized, knowledge on the implications for the design of such games is limited. Firstly, little is known about requirements for the design of LBGs for social interaction (Daneva, 2014; Fonseca, Lukosch, Lukosch, and Brazier, 2020; Isbister and Mueller, 2015; Valente et al., 2017). Secondly, these games

[1] https://mashable.com/2016/07/10/john-hanke-pokemon-go/?europe=true, How the gurus behind Google Earth created 'Pokémon Go', last visited on December 23, 2020.

are most often a product of in-house play-centred development processes (Kasurinen et al., 2014) by experienced practitioners, for which little explicit knowledge is shared and thus not commonly available (Daneva, 2014), nor based on user involvement during design (Eriksson, 2005; Isbister and Mueller, 2015; Nilsen, 2006; Straker et al., 2014; J. Yim and Graham, 2007). Thirdly, there are no known guidelines for the design of activities within LBGs to foster social interaction between players in their own neighbourhoods, to promote playful behaviour (Slingerland, Lukosch, Comes, et al., 2020) or to acquire behavioural change (Avison and Fitzgerald, 2003; Bilandzic and Foth, 2012; Hossenlopp et al., 2007; Paay and Kjeldskov, 2005). Lastly, the types of knowledge needed to design and develop LBGs, ranging from game design and design patterns (Bjork and Holopainen, 2004; Björk and Holopainen, 2006; Dormann et al., 2013; Reuter et al., 2014), to game worlds and the game components and processes needed for very specific gameplay (Avouris and Yiannoutsou, 2012; Eriksson, 2005; Ermi and Mäyrä, 2005; Fonseca, Lukosch, Lukosch, and Brazier, 2020; Fonseca et al., 2017; Korhonen et al., 2008; Naliuka et al., 2010), and to the technical implications for system functionality (Fonseca, Lukosch, Lukosch, and Brazier, 2020; Fonseca et al., 2017; Fonseca et al., 2021; Slingerland, Fonseca, et al., 2020) and architecture (Avouris and Yiannoutsou, 2012; Naliuka et al., 2010; Söbke and Streicher, 2016), have yet to be brought together in cohesive guidelines.

This thesis addresses these knowledge gaps: it 1) explores factors and perspectives that play a role in social cohesion and its upkeep (including social interaction), 2) unveils requirements for local social interaction using an LBG, and 3) advances knowledge on the design of an LBG for social interaction in the neighbourhood of players. The primary focus of this thesis is to understand user requirements, the implications for the design of LBGs, and the evaluation of the extent to which a prototype designed and developed within the context of this thesis fosters social interaction in different neighbourhoods in The Netherlands. The thesis provides a theoretical underpinning of the concept of social cohesion, and proposes a framework with which to characterise social cohesion: this framework identifies levels and possible factors related to cohesion that need to be taken into account to help design interventions. Social interaction is established as a key requirement for more complex social constructs such as cohesion to emerge. This thesis then explores user requirements for location-based games centred on interaction, and proposes several guidelines (gameplay requirements, and design guidelines for game content targeting interaction) based on their needs, to inform future designers of games for social interaction. The thesis also offers insights on the types of social interaction triggered by the created game prototype[2] and how certain forms of interaction have been shown to be meaningful to players. This thesis takes a technical perspective to the problems identified, which is also the lens used in the topic of social cohesion.

The following sections describe the research objective, approach, and outline of the thesis.

1.1. RESEARCH OBJECTIVE

Considering the aim and gaps identified, this study asks the following research question: **"Can location-based games be designed for meaningful social interaction in public**

[2] which is publicly available open source to the community.

space?"

Answering this research question requires understanding of how players ideally interact with each other (from their own perspective) to be able to define requirements for meaningful gameplay. To be able to address the question whether location-based games can be designed, this thesis creates a design, builds a prototype based on the lessons learned, and tests it with players based on requirements gathered. Answering this research question also entails a set of steps detailing how location-based games can be designed for such purpose, as design recommendations. As such, this thesis answers the research question using a step-by-step approach, addressing the following three sub-research questions:

1. **"Which needs and requirements are essential in location-based games for social interaction in public space?"**
2. **"Can a generic system design be created and implemented for location-based games for meaningful social interaction?"**
3. **"Can design recommendations be identified for interaction in location-based games for social interaction in public space?"**

1.2. RESEARCH APPROACH

Addressing the stated research questions requires establishment of new knowledge. A structured approach to the formation of knowledge mandates a comprehensive understanding of the way this knowledge can be found, what establishes knowledge validity, and therefore what is there to be known and by whom[3]. This knowledge comes from a research philosophy that establishes what is deemed acceptable, which also enables researchers to approach their set of research questions through different lenses and sets of methods. This section describes the research philosophy followed in this thesis, the perspective followed, and methods used to address the posed questions.

1.2.1. RESEARCH PHILOSOPHY

This thesis uses a **post-positivist** philosophy as a lens to interpret the findings. Post positivism is a research philosophy created during the twentieth century as a theoretical point of view aiming to amend positivism, that had been the traditional point of view to reveal objective truth (Crossan, 2003). Rooted in the previous century, positivism aligns with philosophy of the age of Enlightenment in the West, that underpins a classical view and an empirical view (Alvesson and Skoldberg, 2009; Crossan, 2003). Positivism's etymology derives from a Latin verbal noun that signifies "to place down, to put" (Alvesson and Skoldberg, 2009). The object to which this action applies to is the objective truth that is present and can be found in reality by a researcher via empirical observation, measurements, and the collection of data (Voulis, 2019). This methodology of discovering knowledge is repeatable, as the researcher stands independently from what is being studied (Alvesson and Skoldberg, 2009; Hirschheim, 1985; Weber, 2004).

Positivism's philosophical view is criticised by post-positivism, primarily based on the fact that the researcher is inseparable from the subject of its study (Alvesson and Skoldberg,

[3] https://plato.stanford.edu/entries/epistemology, Stanford Encyclopaedia of Philosophy, page 4, last visited on December 23, 2020.

2009; Crossan, 2003). Post-positivism recognises the researchers' background, prior experiences, and their own motivation to pursue the research as biases (Crossan, 2003; Ryan, 2006). Therefore, post-positivism does not reject the perspective of an objective truth as posited by positivism, but argues that the observations and measurements are objective whilst recognising the effects of (Alvesson and Skoldberg, 2009; Floden, 2009). The quest for the objective truth is therefore done from different viewpoints, such as for e.g. those from different researchers or techniques, with observations and measurements interpreted as manifestations of larger, underlying patterns (Alvesson and Skoldberg, 2009; Floden, 2009). Unlike positivists, whom argue for the reduction of the scope of the problem to its simplest possible elements, post-positivists embrace more complex problems in their own context, thus considering them as a whole (Crossan, 2003). Post-positivists accept and consider that research can have an open-ended and exploratory character, with one of the consequences thus being the argumentation that both quantitative and qualitative methods are sound to capture knowledge (unlike positivism, which only recognises quantitative methods) (Alvesson and Skoldberg, 2009; Crossan, 2003; Ryan, 2006).

Investigation of a researcher's own biases and their potential impact on the conducted research is essential to a post-positivist approach (Ryan, 2006). The insights and means explored in this thesis are inseparable from the larger perspective that is discussed next.

1.2.2. RESEARCH STRATEGY

With the overarching motivation to foster social cohesion and resilience in local communities, this research has the aim of creating and enabling gameplay experiences based on collective activities designed for meaningful social interaction. Given that "meaningful social interaction" is dependent on the users and how they experience and attribute significance to the gameplay generated by "location-based games", this thesis takes the strategy of **research through design** (RtD) (Zimmerman et al., 2007).

RtD relies on the use of design exercises in the research process, and that distinguishes itself from more traditional user-centred practices[4]. It deploys design as a tool to gain new and better quality knowledge about the users (Zimmerman and Forlizzi, 2014). New and existing artefacts are combined or assembled in new ways to trigger discussions with participants, to create new interaction-based experiences not explored by other traditional practices. These experiences, in turn, are analysed based on scientific methods to generate knowledge (i.e. findings with scientific value) for further theoretical understanding, and novel innovation (Gaver, 2012). With RtD, informed interaction-based research contributions are proposed based on how the world should be transformed, and these contributions are evaluated in their process, invention, relevance, and extensibility (Zimmerman et al., 2007).

Regarding the process, its quality is not assessed based on the reproducibility of the exact same results, but on the rigour applied in the documentation of the contributions and rationale followed for the deployed methods. The evaluation of invention must significantly contribute with novelty, demonstrable through extensive literature reviews (that proves where the world is and what gap is being addressed), and detailing of the technical invention(s) (where the technical implementation(s) and the opportunities of their adoption are passed as guidelines). With regard to relevance, relevance is the benchmark in RtD that replaces

[4] https://mobeedick.com/blog/research-through-design-in-what-way-it-facilitates-innovation/, Research through Design – in what way it facilitates innovation?, last visited on December 23, 2020.

traditional scientific validity and reproducibility of results. Given that different designs can be produced with the same problem or problem framing, argumentation is needed to justify the design aims posed, together with a compelling justification for the reason why the community should consider this design (i.e. the desired impact and relevance to the world). Lastly, RtD evaluates the extensibility of a design: it is defined as the way to build on top of what is designed in the future (lessons learned), whether from the process used, or from the knowledge generated by the produced artefacts.

This thesis follows these criteria throughout the reported studies. The process used is documented, so that future researchers, game design practitioners, and subject-matter experts are able to understand the overall process followed and the reasons for design choices made. Each study reports on the state of the art, current gaps, and the novelty proposed, focusing on the specific innovation and learnings (e.g. guidelines) attained. The relevance is underlined in each study, with the "whys" and "hows" the community should consider. Lastly, each study reported in this thesis proposes future work detailing how the community can extend, complement, or enhance the designed research.

The strategy taken, RtD, is complemented by a combination of **design thinking** (Dorst, 2011) and **systems thinking** (Checkland, 1999). The experiences gained in the studies are triggered by designed artefacts. These artefacts (location-based games) are based on technology that require the design and engineering of software to be built, which, in turn, must address multiple technical and non-technical requirements. The purpose of this software (to facilitate meaningful social interaction) can only be achieved by iteratively eliciting user requirements, and iterating the subsequent developed designs based on these requirements. On the one hand, design thinking provides strategic and practical processes that guide the design of system artefacts (location-based games) based on such iterative requirements: it defines processes to analyse contexts and problems, prototype based on creative processes (such as creative thinking that can be used for requirements elicitation), and testing and evaluation (Dym et al., 2005; Rowe, 1987). On the other hand, Systems thinking is an interdisciplinary theory that defines an ecosystem with smaller and interrelated parts, organised by a structure, and put together in a fashion where its functionalities work together to serve a purpose (Checkland, 1999; Sweeney and Meadows, 2010). Designing and engineering a location-based game that is capable of providing the proposed user experience implies the thinking of: a technical ecosystem, the multiple functionalities that can serve players in their local settings, and the way these are put together to serve the defined purpose (meaningful social interaction in public space). In addition, systems thinking also offers a framework with which the role of users can be defined (M. Brown, 1996), which is a necessity in this study.

The impact of the engineered prototypes developed during this thesis are evaluated in user studies, mainly through qualitative data analysis but also through quantitative data analysis when appropriate.

1.2.3. RESEARCH PROJECT

This thesis takes a combined design thinking and systems thinking perspective. It is part of a wider research project called "Engineering Social Technologies for a Responsible Digital

Future"[5], that is concerned with aspects such as, for e.g., participatory information systems, crowd sourced solutions, gamification, augmented reality, IoT-based real-time measurement of externalities, co-creation tools, and virtual reality approaches (Helbing, 2016). This program contrasts with existent digital frameworks known as "social media", which have increasingly turned into tools to propagate hate speech, fake news, and further social fragmentation on the basis of profit[6].

This thesis advances current understanding on how societies can become more cohesive in the future through the promotion of meaningful social interaction that is carefully designed and sustained by technological artefacts such as location-based games. It aims to face social isolation triggered by multiple factors, such as social ones (e.g. substantial immigration) and "man-made" (e.g. social filter bubbles and echo chambers (Helbing et al., 2019)). It is part of two ongoing sets of studies both aiming at granting users' privacy by design, and designing systems of participation that citizens can trust.

With regard to users' privacy by design, research done has prioritised actual experiments that explore real-life interactions over lab-based agent-based modelling[7]. Games have been explored[8,9,10] for example to understand the willingness of users to share sensor information explicitly against a reward scheme, while having users knowing at all times what they are sharing and while giving them the power to share only when they want to. Other playful approaches with serious games exist, where initiatives for community building and sustainable living[11], and sustainable development through collective action are promoted[12].

With regard to participatory systems' research, this thesis falls in line with previous work that explored how to co-design playful outdoor activities for place making (Slingerland, Lukosch, and Brazier, 2020), how to make individual perceptions of different individuals merge together (Lancel et al., 2019, 2020a, 2020b), how to promote citizen engagement with the neighbourhood (Slingerland, Lukosch, Comes, et al., 2020), how to produce sustainable change in society (Kusnandar et al., 2019), how to jointly share information across citizens (Slingerland et al., 2018), and how to design for the well-being of the most fragile citizens (Kniestedt et al., 2018).

1.3. THESIS OUTLINE

The structure of the thesis is as follows:

- ***Chapter 2*** presents an in-depth literature review on social cohesion, in relation to the design of meaningful social interaction. It proposes a definition of social cohesion,

[5] www.tbm.tudelft.nl/EngineeringSocialTechnologies, Engineering Social Technologies for a Responsible Digital Future, last visited on December 23, 2020.

[6] https://www.thesocialdilemma.com/, The Social Dilemma, last seen December 23, 2020.

[7] https://www.nervousnet.ethz.ch/, Nervousnet, Social sensing by citizens for citizens, last visited on December 23, 2020.

[8] https://apkpure.ai/nervousnet-treasure-hunt, Nervousnet Treasure Hunt, last seen on December 23, 2020.

[9] https://www.apkmonk.com/app/ch.ethz.coss.nervous.competition/, NervousNet Competition Game, last seen on today.

[10] https://www.pnas.org/content/113/30/8414.short, Peer review and competition in the Art Exhibition Game, last seen on December 23, 2020.

[11] http://ena.amsterdam/, Experimental Network Autonomy (ENA), last visited on December 23, 2020.

[12] https://climatecitycup.org, The Climate City Cup, last seen on December 23, 2020.

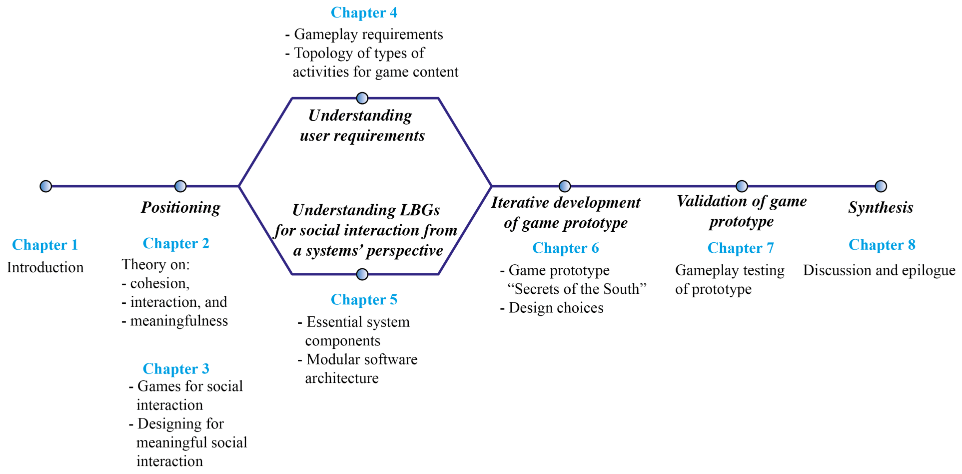


Figure 1.1: Thesis' outline.

a framework in which the roles of an individual, his/her community, and the formal environment are distinguished, and presents meaningful social interaction as a key requirement for social cohesion to be sustained and promoted. Social interaction is then defined, together with a discussion on 1) how to support social interaction, and 2) how it can be meaningful enough to link to social cohesion.

- ***Chapter 3*** takes social interaction as key requirement and positions this thesis on digital location-based games to this purpose. It offers a literature review on existing knowledge about how to design location-based games for meaningful social interaction in public space, by 1) providing an overview of playful approaches developed in urban environments for playful engagement with the physical environment and the people in it; 2) covering existing LBGs designed for social interaction, and existing guidelines/requirements/theory on their design; and 3) presenting a technical perspective on requirements for LBGs from a system's perspective.

- ***Chapter 4*** focuses on user requirements for LBGs for social interaction in local public space, i.e. user preferences, needs and desires. A series of 4 case studies explore these requirements following an iterative requirement design approach with different users (adolescents and adults), in different settings (Rotterdam, and The Hague), and with different tools (game prototypes, and user-centred design techniques).

- ***Chapter 5*** explores how LBGs are designed from the technical perspective to understand the specific functionality required for an LBG for social interaction. This chapter analyses a number of existing LBGs, and identifies key components, and their commonalities.

- ***Chapter 6*** takes the lessons learned from previous chapters to create a game concept implemented in a game architecture and prototype. This chapter details the game concept, game architecture design, and the design choices made.

- ***Chapter 7*** presents the case study in which the game prototype presented in the previous chapter is validated with respect to meaningful social interaction. This chapter proposes design recommendations that can support practitioners in the creation of such games in the future.
- ***Chapter 8*** concludes this thesis by discussing the results in relation to the initial research questions posed, how the lessons learned throughout address these questions, discussing implications of findings and directions for future work.

2

Understanding Social Cohesion: A Literature Review

The increasing segregation we have in our country geographically and culturally has led to these pretty monolithic views of different classes of people, and because of that, we've lost a certain amount of cultural cohesion.

J. D. Vance

To address social cohesion, first, we need to understand what it is. This chapter offers a literature review on social cohesion (not from the social science's perspective, but from one that wants to position this research). This chapter analyses how consistently social cohesion has been defined over time, and discusses the different points of view on social cohesion and how they all link together, while arguing about the points of view that benefit from further research. This work 1) updates current definitions of social cohesion with one that better matches the multicultural nature of current societies, 2) proposes a framework to help identify what impacts social cohesion and can thus be used to foster it, and 3) argues that social interaction is one of the major requirements to promote and sustain cohesion. Social interaction is then defined, and a discussion is held on 1) how it can occur, and 2) how it can be meaningful enough to link to social cohesion.

This chapter is based on the published article: X. Fonseca, S. Lukosch, and F. Brazier, *Social Cohesion Revisited: A New Definition and How to Characterize it*, In Innovation: The European Journal of Social Science Research, vol.32, no. 2, pp. 231-253, 2018 (Fonseca et al., 2018b).

2.1. Method of Review

By using the Google™ search engine and searching for 'books on social cohesion', and by considering the first 10, the result is a fairly up-to-date starting point (ranging from the years of publication between 1999 and 2016) (Bruhn, 2014; Dobbernack, 2016; Dragolov et al., 2016; Gough and Olofsson, 1999; Hickman et al., 2012; Jenson, 2010; Larsen, 2013; Mizukami, 2016; Reitz et al., 2009; Vertovec, 1999). The books were then studied one by one, and the references lists of all of them were screened for a further in-depth analysis of relevant articles on the concept of social cohesion alone. Three methodological approaches (theoretical and empirical, experimental, and social network analysis) (Bruhn, 2009) are discussed. This approach also indicated a relevant period from late nineteenth century and today.

The initial analysis was complemented with further research on the experimental studies on social cohesion in the same period and that were not already mentioned using the previous method. This was done by searching on Google™ Scholar for experimental studies on social cohesion with the criteria 'experimental' AND 'studies' AND 'social cohesion'. This review considers the first relevant 100 results (from today backwards), where relevant means that the whole experiment was motivated by social cohesion and applied to humans, which discards publications that briefly mention social cohesion, study social cohesion in species other than humans, had some analysis to offer in populated areas of the world (excluding the poles), or that do not even use 'social cohesion' as a term in neither the title, the abstract, or as keyword.

2.2. Perspectives on Social Cohesion

Key research on social cohesion started from late 19th century, and has been addressed by different disciplinary perspectives (Psychology, Social Psychology, Sociology, Mental Health, and Public Health), and cover different scopes (from smaller groups, to larger societal groups). Studies on social cohesion are clustered around three methodological approaches throughout the centuries: on theoretical findings and empirical research, experimental studies, and social network analysis (SNA) (Bruhn, 2009). Below, key research is presented chronologically, and organised by these three distinct approaches. Each approach offers different insights, and all contribute in their own way to the overall complex construct of social cohesion.

2.3. Theoretical and Empirical Studies

This section develops a timeline with key theoretical and empirical studies. Information is presented in a way to convey three messages to the reader: 1) which researchers are, and were, key to the development of social cohesion as a construct, 2) how social cohesion has been defined over the centuries, both in general and specific terms, and 3) which topics/factors on social cohesion have been associated over time. This timeline is visually represented in figure 2.1, sums up points 1) in black, 2) in green and 3) in blue, and is developed thereafter.

Major research in social cohesion starts with Le Bon with the theory of collective behaviour and contagion (Le Bon, 1897). He distinguishes different types of crowds or communities, and that these have a multiplicity of characteristics, opinions and beliefs that impact the individuals in a crowd. In 1897, Durkheim defines social cohesion as a characteristic of society that shows the interdependence in between individuals of that society (Berkman et al., 2014), and coins to social cohesion 1) the absence of latent social conflict (any conflict based on for e.g. wealth, ethnicity, race, and gender) and 2) the presence of strong social bonds (e.g. civic society, responsive democracy, and impartial law enforcement) (Durkheim, 1897). Cooley presents in 1909 the idea of primary groups, as groups having intimate face-to-face communications, dynamics of cooperation and conflict in between elements, and high numbers of friendships stemming from a substantial time spent together, which, when absent, can foster social disorganisation (Cooley, 1909).

In 1921, Freud supports Le Bon's opinion about the unconscious identification of individuals, and defines social cohesion as the identification of one individual with others that share the same characteristics and provide intense emotional ties (Freud, 1923). At the same time, McDougall defines group cohesion as the intrinsic collective mentality with levels of reciprocity and a common way of feeling and thinking (McDougall, 1920). Further ahead, Lewin defines a group as a dynamic whole with its own size, organisation, and intimacy (Lewin, 1946), and argues that individual behaviour is a product of both the person and the social environment, relating therefore agency of the individual to what the surrounding social context affords him/her.

In 1950, Festinger et al. come up with a definition of group cohesiveness that many researchers use thereafter (Festinger et al., 1950). For them, group cohesion is the desire of individuals to maintain their affiliation with a group, and this drive is measured by influence and initiative, task competence, and especially like-dislike. Cartwright endorses Lewin's theory of power field by arguing that power is not a trait of an individual alone, but from bilateral relationships that mediate formal or informal control (Cartwright, 1951). Homans argues in 1958 that the higher the value of the rewards coming from the set of negotiated exchanges in people's friendships, the bigger the group's cohesion (Homans, 1958). French and Raven also follow Lewin's field theory, and define seven sources of social power that affect groups' dynamics and cohesion (connection, expertise, information, legitimacy, reference, reward, and coerciveness) (French et al., 1959). Lott and Lott discover that the degree of liking is an indicator of group cohesion (A. J. Lott and Lott, 1966), and advance a new definition of social cohesion as a group property that is induced from the amount and strength of reciprocal positive attitudes among individuals of a group (A. J. Lott and Lott, 1961). Janis describes pressures for conformity in collective decisions observed in cohesive groups, even when these are wrong (Janis, 1972). Granovetter complements the theory of primary groups by looking at the strength of weak ties. Social cohesion is affected by how much the friendship networks of individuals of different groups overlap (Granovetter, 1977). In 1983, Stokes supports previous studies on the degree of cohesion and quality of information disclosed to other members, by defending that group cohesion is enhanced whenever intimate topics are shared in between individuals of the group, and whenever individuals adopt a balanced risk-taking behaviour (J. P. Stokes, 1983). Braaten defines group cohesion as the equivalent of good relationship for an individual, which, when present, can help an individual to become the person h/she strives to be. He researches factors like group cohesion and its role in a good relationship, and creates a multidimensional model that supports the establishment, support, and achievement of a high level of cohesion (Braaten, 1991).

Maxwell suggests a first definition for social cohesion for the Canadian Policy Research Networks: 'Social cohesion involves building shared values and communities of interpretation, reducing disparities in wealth and income, and generally enabling people to have a sense that they are engaged in a common enterprise, facing shared challenges, and that they are members of the same community' (Maxwell, 1996). Alaluf defends that cohesion is promoted by the social system delimited by the nation, and defines it as a sense of a nation (identity) as a whole (unified), as represented by distinctive traditions, culture, and language[1] (Alaluf, 1999). Lockwood defines social cohesion as the strength of primary and secondary networks, which adds to the studies of Cooley (primary groups) and Granovetter (weak ties) (Lockwood, 1999). He defends that social cohesion manifests in voluntary associations and family organisation, in the absence of traditional crime, and that civic society and social cohesion are linked via secondary associations.

[1] https://en.oxforddictionaries.com/definition/national_identity, Definition of national identity, last visited on December 23, 2020.

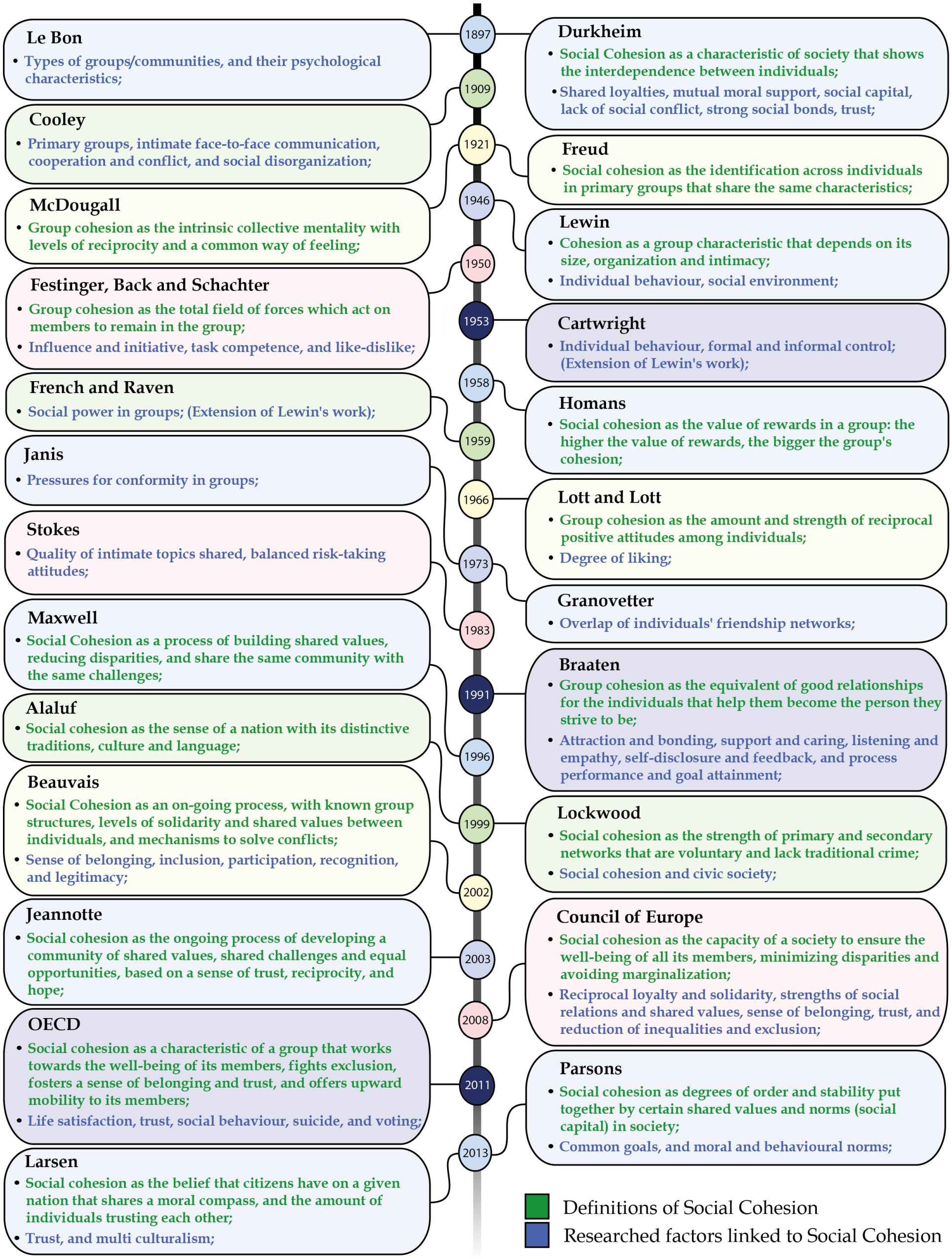


Figure 2.1: Theoretical and empirical studies.

Beauvais defines social cohesion as an on-going process, with known group structures, levels of solidarity and shared values between individuals, and with mechanisms to solve conflict, while arguing that it is comprised of 5 different dimensions (belonging, inclusion, participation, recognition, and legitimacy) (Beauvais and Jenson, 2002). Jeannotte updates the definition of Maxwell in 2003 (and still in use today): 'the ongoing process of developing a community of shared values, shared challenges and equal opportunity within Canada, based on a sense of trust, hope and reciprocity among all Canadians' (Jeannotte, 2003). The Council of Europe defines social cohesion as 'the capacity of a society to ensure the well-being of all its members, minimising disparities and avoiding marginalisation' (CoE, 2008) with the following characteristics: 1) reciprocal loyalty and solidarity, 2) strength of social relations and shared values, 3) sense of belonging, 4) trust among individuals of society (the community), and 5) reduction of inequalities and exclusion. The Council of Europe (CoE) still uses this definition today[2]. The OECD presents its concise definition that relies on three independent pillars: social inclusion, social capital, and social mobility: 'A cohesive society works towards the well-being of all its members, fights exclusion and marginalisation, creates a sense of belonging, promotes trust, and offers its members the opportunity of upward mobility' (de Cooperación y Desarrollo Económico, 2011). Parsons researches how politics, religion, family, education, and economics are functional for a society, and considers social cohesion as levels of order and stability put together by shared norms and values in society (T. Parsons, 1991). These enable individuals to identify and contribute to common goals, and share moral and behavioural norms that function as a base for interpersonal relationships. Larsen defines cohesion as the belief that citizens have on a given nation that shares a moral compass, which in turn provides a common ground for trust (Larsen, 2013). It is then defined and measured by the amount of individuals trusting each other in some degree (national identification and belief).

2.4. EXPERIMENTAL STUDIES

Experimental studies on social cohesion have an exploratory approach and can be categorized into three general types of experiments: 1) observational, 2) manipulation of group cohesion or test of its resilience, and 3) experiments fostering social cohesion. Experiments in the observational category regard measurements through observation of certain group conditions that are recorded via some quantitative method (either a scale, a questionnaire, or other form of annotation). Experiments in the manipulation of group cohesion or test of its resilience are experiments in which experimenters directly influence the cohesiveness of a group (or challenged it). Lastly, the experiments on fostering social cohesion fall into the third category, by mainly changing initial test conditions and then letting the group change its level of cohesion without further influence of the researchers.

This section develops each of the 3 types of experiments in subsections, each with a respective timeline and chronological presentation of studies. These timelines on experimental studies have two messages for the reader: 1) to show what the mentioned researchers consider to be relevant in social cohesion, and what they researched/measured, and 2) what researchers find. Each timeline presents a colour scheme to help the reader understand the nature of the research covered, and how often it was covered.

[2] http://www.coe.int/t/dg3/, last visited on December 23, 2020.

2.4.1. Observational Measurement

Figure 2.2: Timeline experimental studies, observational measurement approach.

Moreno researches the existent structures of social groups and their group dynamics based on forces of attraction and repulsion (Moreno, 1934). He discovers in 1934 that group dynamics are shaped by the choices and patterns individuals take in regard to their relationships. Lippitt researches the impact of different leadership styles in group cohesion, and argues that group cohesion is higher when the leader is democratic, as it is highly influenced by whether individuals have their expectations met (Lippitt, 1943; Lippitt and White, 1943). Polansky looks at how social behaviour and interaction is influenced by other individuals, and finds out that the status in a group is an important determinant of both susceptibility and actual instigation of contagion behaviour in others (N. Polansky et al., 1950). Carron studies the theory of group dynamics, and defines a multidimensional model with several aspects linked to cohesion and the relationship between the group and the individual (Carron et al., 2005; Carron et al., 1985). He defines group cohesion as a process of remaining together and united, with all the individuals' needs met. Silbergeld researches the psycho-social atmosphere of different therapy groups, and creates a scale that measures group environment and several indicators of both group cohesion and conformity (Harpine, 2011; Silbergeld et al., 1975). Mackenzie analyses both the leaders' skills and groups' climates, and develops a questionnaire to measure group cohesion via the individual's engagement, conflict, and avoidance (MacKenzie, 1981; MacKenzie et al., 1987). Piper focuses on the perceptions that individuals have from other members of the group, the leader, and the group as a whole, and uses these to define group cohesion as the result of the set of bonds that exist in a group (Piper et al., 1983).

Budman relates group cohesion with individuals' perceptions of outcome in the group, and defines 3 metrics to quantify social cohesion: 1) individuals acting together towards a common goal, 2) positive engagement around common goals, and 3) a vulnerable and trusting attitude that fosters the sharing of private materials (Budman et al., 1987; Fuhriman and Burlingame, 1994). Brawley researches the relationship between cohesion and the behaviour of athletic teams and their individuals, and designs a questionnaire to measure multiple aspects of perceived cohesion in groups. He manages to validate both the group integration and individual attractions to the group as predictors of group cohesion (Brawley et al., 1987). Meyer compares scores of two questionnaires (group environment and sport orientation) on group cohesion and attitude towards competition of athletes (Meyer, 2000). She finds out that cohesion of co-acting teams is more strongly related to individual or social factors than it is the overall focus or goal of a team. Vianen examines the relationship between personality composition and team performance, and defends that 1) conscientiousness and agreeableness contribute to task cohesion, 2) levels of extroversion and emotional stability fostered social cohesion, and 3) task characteristics are a substantial factor influencing group personality, group dynamics, and group performance (Van Vianen and De Dreu, 2001). In 2002, Carron analyses the relationship between task cohesiveness and group success, while looking also at individuals' perceptions of the group's cohesion and how these relate to group consistency (Carron et al., 2002). His analysis reveal that cohesiveness is a shared perception, and that there is a strong relationship between cohesion and success.

Peterson defines social cohesion as a construct linked to community participation with notions of trust, shared emotional commitment and reciprocity (Peterson and Hughey, 2004). While furthering this notion, he investigates whether gender interacts with social cohesion to predict intrapersonal empowerment. He shows that the effects of social cohesion on intrapersonal empowerment are different for females and males, due to different participatory experiences related to social connectedness. Groenewegen studies health, well-being, and feelings of social safety, and looks at how social cohesion is affected by local green areas (Groenewegen et al., 2006). He argues that attractive green areas in the neighbourhood may serve as a focal point of tacit coordination for positive informal social interaction, which strengthens social ties and social cohesion. Høigaard looks at the relationship between group cohesion, group norms, and perceived social loafing, and discovers that the combination of high social cohesion, low task cohesion, and low team norms seems to underlie perceptions of social loafing (Høigaard et al., 2006). Echeverría examines the association between social cohesion and several mental health and health behaviour problems (Echeverria et al., 2008). She associates less socially cohesive neighbourhoods with increased mental health problems and poorer health habits, regardless of race/ethnicity. Kim researches the relationship between social capital and health (public, mental, physical, health-related behaviours, and ageing outcomes), and conceptualises social capital as an attribute of a cohesive group (D. Kim et al., 2008). He points out that social relationships have, and produce, valued resources (capital), which exist in cohesive groups. Ball examines the associations between social participation of individuals, the neighbourhood's interpersonal trust, and physical activity among women, and argues that women are more likely to participate in leisure-time physical activity when they participate in local groups or events taking place in neighbourhoods where residents trust one another (Ball et al., 2010).

Mair analyses associations of neighbourhood stressors (perceived violence and disorder, and physical decay and disorder) and social support (residential stability, family structure, social cohesion, reciprocal exchange, social ties) with depressive symptoms, and argues that depressive symptoms are both positively and negatively associated with, respectively, neighbourhood stressors, and social support factors (Mair et al., 2010). Verkuyten studies in 2010 whether assimilation of information affects the relationship between ethnic self-esteem and situational well-being (Verkuyten, 2010). He shows that ethnic self-esteem is positively related to feelings of global self-worth and general life-satisfaction, particularly when information undermines the individual's ability to live their ethnic identity and threatens their group's positive distinctiveness. De Vries furthers the work of Groenewegen by focusing on green spaces and in three particular mechanisms through which greenery might exert its positive effect on health: stress reduction, stimulating physical activity and facilitating social cohesion (De Vries et al., 2013). His study confirms that green spaces of quality reduce stress and facilitate social cohesion.

Gilligan studies in 2014 the effects of wartime violence on social cohesion, and discovers that violence-affected communities exhibit higher levels of pro-social motivation, measured by altruistic giving, public good contributions, investment in trust-based transactions, and willingness to reciprocate trust-based investments (Gilligan et al., 2014). At the same time, Whitton makes further analysis on the group environment questionnaire by accounting for the hierarchical nature of group data collected, and her analysis suggests that cohesion is a group-level construct (Whitton and Fletcher, 2014). Aletta investigates an open public space used mainly as a pedestrian crossing to analyse the relationship between the audio stimuli and peoples' behaviours (Aletta et al., 2016). The results support the idea that the acoustical manipulation of the existing sound environment could provide soundscape strategies capable of promoting social cohesion in public spaces. Ohmer argues that low-income communities can prevent violence and its extensive consequences by developing collective efficacy (the sharing of norms and values, trust one another, and willingness to intervene to address common problems) (Ohmer, 2016). She proves that the increase of collective efficacy includes social capital and social cohesion.

2.4.2. Manipulation of Group Cohesion or its Resilience

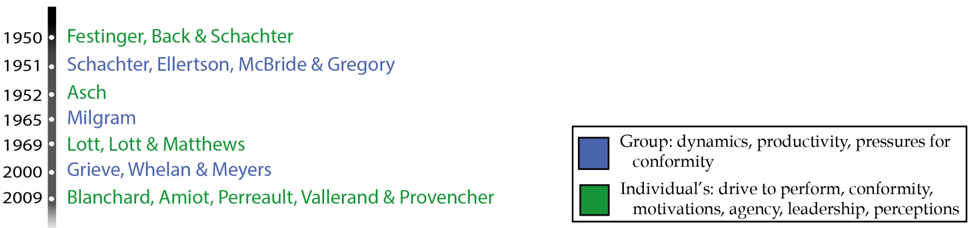


Figure 2.3: Timeline experimental studies, manipulation of experimental studies approach.

Festinger investigates the way that face-to-face interactions in small groups impose pressure upon individuals to follow group norms (Festinger et al., 1950). He argues that individuals have a drive to be accurately self-evaluated, and this affects group formation and group structure. In the following year, Schachter researches productivity in a group, and finds out that more cohesive groups are more successful at influencing their members (Schachter et al., 1951). Asch argues that people want to be liked, and therefore conform more or less depending on the forces opposing them in the group (Asch, 1952). He finds out that 75% of the participants in his experiments change opinions at least once, especially when they are the only ones with a contrary judgement.

Milgram experiments on both the theory of pressures of conformity and on resilience of the cohesiveness of the group, and finds out that individuals go almost to any length in harming others in order to conform to given orders (Milgram, 1965). Lott researches how different individuals' agencies in a group affect their positive attitudes towards other members (A. J. Lott and Lott, 1969). He also researches interpersonal attitudes that involve people who evoke attitudes, and supports the hypothesis that liked individuals can function as effective positive reinforcers and disliked individuals the opposite. Grieve examines the cohesion-performance relationship, and his results indicate that performance has more impact on cohesion than cohesion has on performance (Grieve et al., 2000). Blanchard researches intrinsic and extrinsic motivations' impact on group cohesion, and finds out that individual perceptions of cohesiveness positively predict the satisfaction of the basic psychological needs of individuals (Blanchard et al., 2009).

2.4.3. Fostering of Group Cohesion (Manipulation of Initial Variables)

Figure 2.4: Timeline experimental studies, fostering of group cohesion approach.

Deutsch researches the influence of rewards on social cohesion based on cooperation and competition (Deutsch, 1949). He finds that these have a substantial impact on social cohesion: 1) groups that are rewarded on a cooperative basis are more cohesive than those on a competition basis, and 2) group dynamics play a bigger role than the goal of the group when it comes to member's motivation to stay in the group. Sherif researches conflict, and how common tasks can mitigate conflicts and promote social cohesion (Sherif and Sherif, 1969). He learns that common activities, both in between different groups and with all members together, result, respectively, in inter-group hostility, and inter-group cooperation (both with high in-group bonds). Hogg discusses psychological group formation, and whether this is linked to social cohesion (interpersonal attraction) or social identity (personal identification), and his findings prove that groups are formed due to motives of personal identity and not for existent social cohesion (Hogg and Turner, 1985).

2.5. Social Network Analysis' Studies

Social Network Analysis (SNA) attempts to bridge the gap between different scopes of the several scientific disciplines by looking at all network levels of society - individual, micro, meso and macro (Persell et al., 1984; Phillips, 2006) - through the theories of networks and graphs. SNA characterizes network structures through individuals and the ties connecting them that represent the relationships or interactions (D'Andrea et al., 2010).

This section develops a timeline with the key studies on SNA. Information is presented in a way to convey two messages to the reader: 1) the researchers responsible for furthering the comprehension on social cohesion through SNA, and 2) the researched topics/factors that these key studies focused on. This timeline is visually represented in figure 2.5, sums up points 1) in green and 2) in black, and is developed thereafter.

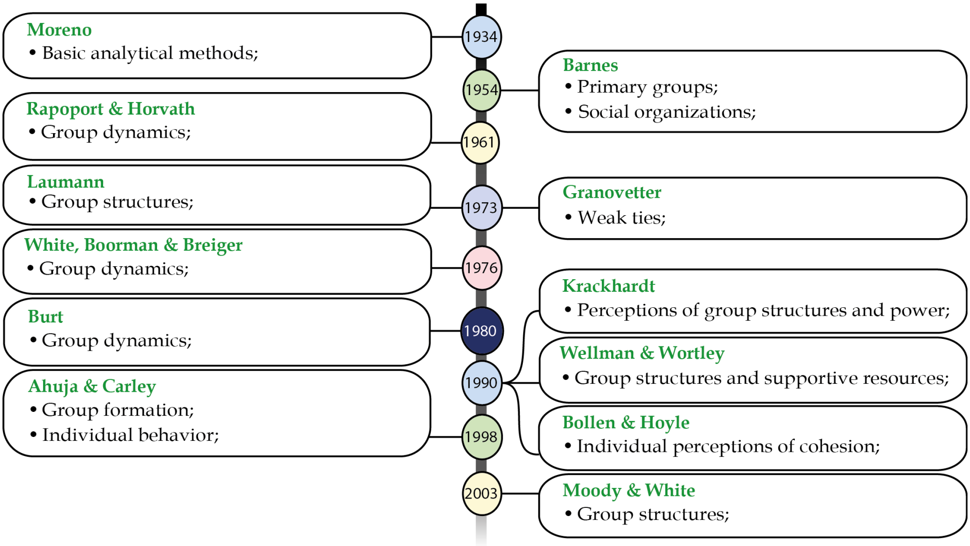


Figure 2.5: Timeline SNA's studies.

With the foundation of Sociometry in 1934, Moreno introduces basic analytical methods, and, twenty years later, Barnes studies social organisation of class and committees while pinning SNA to explain patterns of ties, primary groups and social groups (Barnes, 1954). Rapoport and Horvath are also among the early developers of SNA by showing that it is possible to measure higher-level networks by studying relationships' dynamics through them (Sociometry) (Rapoport and Horvath, 1961). Laumann creates social network surveys to display ethnographic and religious structures of different classes of social networks at higher levels than the individual (Laumann, 1973), and, at around the same time, Granovetter contributes with his theory of the strength of weak ties, in which SNA is a central piece to link society at both micro and macro levels (Granovetter, 1977).

White contributes in the 1960s to a well-developed methodology for SNA by developing models that combines patterns of relationships into descriptions of social structures (White et al., 1976). Burt describes social differentiation in terms of interpersonal patterns among individuals in a system (Burt, 1980), i.e. some network models treat relationships among all individuals whilst others describe the relations in which an individual is involved. Krackhardt uses SNA to affirm that a better perception of the shape of informal networks can in itself be a base of power (Krackhardt, 1990), which is perceived to be well above the power attributable by formal structural hierarchies. At the same period, Wellman and Wortley advance the definition of communities as personal networks no longer confined to geographical areas and with the capability to provide with different kinds of supportive resources (Wellman and Wortley, 1990). Still in 1990, Bollen and Hoyle look at the same time at the perceptions of cohesion of members of a group at both the individual level (perceived cohesion is the role of the group in the life of the member) and group level (the role of members in the life of the group) (Bollen and Hoyle, 1990).

Ahuja and Carley use SNA to develop a simulation model for individual behaviour that analyses how groups keep their distinctiveness throughout the intake of new members and ideas (Ahuja and Carley, 1998, 1999). Moody and White define 1) the structural cohesion of a network as the minimum number of individuals that needed to be in the group for it not to become disconnected, and 2) the structural dimension of embeddedness as the tiered nesting of cohesive structures in the network (Moody and White, 2003).

2.6. Definition of Social Cohesion

Literature shows that there is a fragmented view of what social cohesion is. It is best defined by the absence of conflict or crime (Durkheim, 1897), a characteristic of society (CoE, 2008), a desire for affiliation (Festinger et al., 1950), a group property (A. J. Lott and Lott, 1966), a degree of stability (T. Parsons, 1991), the strength of connections (Braaten, 1991), as a transient state/process (Jeannotte, 2003), and the same as good relationships or a national identity (Alaluf, 1999) (which might not be true in current multicultural societies). Some definitions (de Cooperación y Desarrollo Económico, 2011; Jeannotte, 2003) started to be adopted worldwide (e.g. in European Union, Canada and Australia), likely because these also considered the economic sphere of society along with the general well-being and equal representation/opportunities in society. These more widely adopted definitions aim at defining cohesion at a level that is wide enough for a whole society and not for small groups only.

2.6.1. Three Levels in Social Cohesion

There are certain perspectives that are consistently used to study social cohesion, and these are seen to be levels that should be considered to acquire comprehensive understanding on the complex construct that is social cohesion. The three levels (the individual, community, and institutions) are described here under, and coined to the respective research(ers) as well.

Level of the Community. The level of community is, for e.g., the shared loyalties, mutual moral support, social capital, strong social bonds, trust, social environment, formal and informal control, overlap of individuals' friendship networks, pressures for conformity and caring, civic society, reciprocal loyalty and solidarity, strength of social relations, shared values, common goals, moral behaviour and norms, values of rewards in groups, and process performance and goal attainment.

In theoretical and empirical studies (e.g. from Durkheim (Durkheim, 1897), cohesion started initially to be studied through the level of the community/society. Research on the topic starts off with collective behaviour and group contagion, different groups and their characteristics/beliefs, the interdependence between individuals and the importance of other people for the individual (primary or secondary social ties to the individual and how much these overlap), the collective mentality of groups, the agency or power of the individual that is highly affected by others in the community, the errors made by groups and not by individuals alone, and the quality/intimacy of the topics shared in group. Cohesion is studied in groups of individuals, and even understood as the quantity/quality/type of social capital coming from the social relationships. The definition of social cohesion from the Council of Europe (CoE, 2008) is linked to this level of the community through the shared values of reciprocity, loyalty, and solidarity, and the quality of social relations that includes the value of trust, a definition that is extended by Maxwell and Jeannote (Jeannotte, 2003; Maxwell, 1996). Adding to this level of the community are also the values of moral compass, national identification and belief.

On to experimental studies, a sizeable amount of research done gives strength to the perspective on the community. Researchers focused for e.g. on the different group dynamics, group goals, and all the processes that occur in between individuals. Carron (Carron et al., 1985) and Deutsch (Deutsch, 1949) focus on group dynamics like competition vs. collaboration towards group goals, which relates to both Mackenzie's work on group climate and Budman's experiments on individuals acting together towards common goals. Also covered are the in-group processes of group influence and leadership styles of Lippit (Lippitt, 1943), which relates to Polansky work on the status an individual has in a group and the susceptibility and instigation of contagion behaviour in others (N. Polansky et al., 1950). These studies also relate to the group processes studied by Lott and Sherif (A. J. Lott and Lott, 1969; Sherif and Sherif, 1969), which looked at individuals as positive and negative reinforcers for the group, alongside inter-group processes of hostility and cooperation.

Level of the Individual. The level of the individual is, for e.g., the individuals' intimate face-to-face communication, task competence, degree of like-dislike, initiative, individual behaviour, quality of intimate topics shared, sense of belonging, inclusion, individual participation, recognition and legitimacy.

Theoretical and empirical studies on social cohesion often take the point of view at the level of the individual. This level was first brought by Freud's work (Freud, 1923), with the individual's identification with the group, which focuses more on the motives of the individual to be part of a group. Festinger, Back and Schachter's definition on social cohesion also strengthens Freud's argument on the role of the individual in cohesion and his/her desires to belong to a group and stay in it (Festinger et al., 1950). This level of the individual is also furthered through the importance of the degree of liking as a personal reward to belong and maintain affiliation with a group - the amount of personal reward. Braaten adds to the studies of these researchers by arguing that groups, when capable of bringing a good relationship to individuals, help them become who they desire to be (Braaten, 1991). This desire of the individual also goes along with the argument from Beauvais (Beauvais and Jenson, 2002) and the definition of social cohesion from the Council of Europe (CoE, 2008), which mention the degree of belonging of the individual, and how much it affects the degree of participation in the group.

On experimental studies, researchers also cover this level well by for e.g. measuring personal feelings and general attitudes towards other individuals. Researchers like Moreno (Moreno, 1934), Asch (Asch, 1952) and Milgram (Milgram, 1965) study levels of liking and disliking, degrees of likeability and conformity in the group, which relate to the work of Piper on the individuals' perceptions from other members of a group (Piper et al., 1983), and the work of Lott on positive attitudes towards other members (A. J. Lott and Lott, 1969). Many of these works also precede the study on individual engagement (namely from Mackenzie and Budman - (Budman et al., 1989; MacKenzie et al., 1987), which also consider aspects like conflict and avoidance, positive participation in group's activities, vulnerable and trusting attitudes, and the sharing of personal data in between individuals.

Level of the Institutions. The level of institutions consists of, for e.g., social disorganisation, lack of social conflict, life satisfaction, voting, social behaviour, suicide rates, civic society, trust and multiculturalism, and reduction of inequalities and exclusion.

In theoretical and empirical studies, research identifies several relevant factors that play a role in social cohesion and that consistently point out the need for a balanced society with equal opportunities and rights for all citizens. Factors like impartial law enforcement, civic society, and responsive democracy are mentioned now and then by researchers like Durkheim and Lockwood, which underline the importance of social contexts and different styles of governance in variables such as wealth, ethnicity, race, and gender. Durkheim shed light on the role of the 'formal' context of societies for cohesion, implying that the unequal or ill-structured context of societies (affected by, for e.g. law-making) hinders cohesion (Durkheim, 1897). Lockwood added a distinction of social integration (actors) and system integration (structure), which covers the absence of traditional crime, voluntary associations and family organisations (civic society) (Lockwood, 1999). This highlights the need to account for the role of formal institutions or societal bodies (that can aid citizens and intervene for them) in the debate on social cohesion. This is also coherent with the need for inclusion mentioned by Beauvais (Beauvais and Jenson, 2002), the reduction of inequalities and exclusion mentioned by the Council of Europe (CoE, 2008), and the equal opportunities and upward mobility from the definition of the OECD (de Cooperación y Desarrollo Económico, 2011), which can be provided by governments and formal institutions (e.g. NGO's) best.

To the best of our knowledge, the perspective formal institutions is not taken in experimental studies on social cohesion, or merely not coined to the literature on social cohesion. This means that future studies designed to research social cohesion should consider the perspective of institutions, as it does not seem to have been covered in a substantial way.

2.6.2. ABUNDANCE OF STUDIES AND THE THREE LEVELS

Theoretical and empirical studies are abundant, and so are most of the experimental ones. On experimental studies, there is a lack of research that manipulate group cohesion or its resilience (figure 2.3), and also research that seeks to foster social cohesion by altering initial conditions and testing these out (figure 2.4). The majority of the experimental studies focus on observing group dynamics and individual behaviour in regard to a group (and collecting data through scales or questionnaires), as shown in figure 2.2. These focus on observation of group dynamics from a distance (without disturbing the pre-existent in-group processes), and do not focus on manipulation of group cohesion or test of its resilience, or on trialling different group configurations or initial variables (and assess whether these foster or hinder cohesion). Particularly on experimental studies that aim at fostering group cohesion by manipulating initial variables only, the last recorded study is in 1985, and while this is not a scientific finding, it might be interesting to understand why this might be the case. In terms of SNA's studies, they focus on different levels and topologies of groups in society. They focus on how well or loosely coupled individual links are connected to the overall group, and on how these different topologies affect group characteristics like the overall cohesion or connectedness of that group. Studies through SNA prove to enhance the understanding of social cohesion in a way that experimental studies are not able to (for e.g. the strength of weak ties (Granovetter, 1977) and overall ethnographic/religious social structures (Laumann, 1973) that focus on the boundaries of groups at meso/macro levels).

As discussed in the following, it is not common to see research on social cohesion covering all three levels. Most of the studies cover the individual and the community, but they mostly miss the role of governance and formal institutions in society that are responsible for, for e.g., the social environment (and its structures, norms and values), for decision making, conflict management, social upward mobility, or human rights like voting or access to basic commodities. Researchers like Parsons consider the level of institutions in his definition (T. Parsons, 1991), but do not cover the level of the individual, while others like Larsen focus on the levels of individual and community, but fail to mention the role of formal institutions (Larsen, 2013). The three levels do appear in some research. They can be observed in several of the definitions of social cohesion widely used today, and, particularly, in those from the Council of Europe (CoE, 2008), Jeannotte - used by the Canadian government (Jeannotte, 2003), and from the OECD (de Cooperación y Desarrollo Económico, 2011).

Cohesion happens in the intersection of the three mentioned levels, and therefore all three levels need to be considered to understand social cohesion. An individual might have the motivation to belong to a group and the drive to participate and perform in it, but if the formal structure of the country does not allow citizens to act, then social cohesion is hampered. This means that the environment of individuals dictates their agency, i.e. the individual's freedom to act and choose that is directly conducive to the well-being of the individual (Ibrahim and Alkire, 2007). For individuals to act, they need favourable communities (climate with compatible sets of norms and values) and institutions (formal structures, norms and values) that do not forbid or limit the individual's actions and choices. Further research is necessary though, in order to understand how these are linked.

2.6.3. Redefinition of Social Cohesion

Current definitions of social cohesion do not cover the multiplicity of values and cultures found in current societies, and, as a result, current societies might be governed and shaped around a construct that can also contribute to substantial/chronic conflict.

Larsen made a pertinent argumentation about the globalized multiculturalism and how it might go against the idea of similarity of mind and the shared values required to establish trust (and cohesion to a bigger extent) (Larsen, 2013). He defended that heterogeneity of society and all its diversity goes against social cohesion because a cohesive society shares a moral compass (ground for trust). This implies that there cannot be generalized trust among different clusters of individuals with different cultures and values[3]. Failure to achieve acceptance towards all forms of human kind and their diverse expressions leads through the course of time to a fragmented and negative cohesion (Cheong et al., 2007). Mixed

[3] https://www.merriam-webster.com/dictionary/morality, Definition of morality, last visited on December 23, 2020.

neighbourhoods are better than separated clusters of highly cohesive communities (negative cohesion), as they offer a more open-ended engagement, vibrant opposition, and strike a balance between cultural autonomy and social solidarity.

Table 2.1 shows three current definitions widely in use today, which, however, do not fit current societies. For e.g., these mention the well-being of all its members, but while referring to the 'shared values', they do not stress the diversified nature these can have (i.e. regardless of the background of the individual), along with the tolerance required from individuals to cohabit with others fundamentally different from them; 'fights exclusion and marginalisation' can happen simply within 'local' ethnicities as well, 'reciprocity' is mentioned without stressing the agency and personal motivation of the individual to belong and act (voluntary social participation), and none of the three definitions addresses or stresses the diversity of values - especially those rooted in different backgrounds.

Council of Europe (CoE, 2008)	Canadian Government (Jeannotte, 2003)	OECD (de Cooperación y Desarrollo Económico, 2011)
'... the capacity of a society to ensure the well-being of all its members, minimising disparities and avoiding marginalisation'	'... the ongoing process of developing a community of shared values, shared challenges and equal opportunity within Canada, based on a sense of trust, hope and reciprocity among all Canadians'	'A cohesive society works towards the well-being of all its members, fights exclusion and marginalisation, creates a sense of belonging, promotes trust, and offers its members the opportunity of upward mobility'

Table 2.1: Definitions of social cohesion widely in use today.

Due to the fact that existent definitions fail to address the multicultural component of current societies, this research offers a new definition of social cohesion. This study combines the 3 definitions exposed in table 2.1 into one generic definition, while stressing the important role of multiculturalism, and the values of tolerance, voluntary participation, and diversity in society that embellish the construct of cohesion:

> **The ongoing process of developing well-being, sense of belonging, and voluntary social participation of the members of society, while developing communities that tolerate and promote a nationwide multiplicity of values and cultures, and granting at the same time equal rights and opportunities in society.'**

2.7. Social Cohesion Framework

This section proposes a framework with which to analyse the levels and aspects that are not always accounted for, regardless of the perspective taken (theoretical and empirical, experimental, or SNA). This open generic framework is used to characterise social cohesion (as a complex and dynamic concept), made up of multiple and smaller levels that can help to quantify it. Figure 2.6 presents the generic social cohesion framework (SCF) with the same three different but intertwined levels identified in the literature (and accounted for in the definition).

The framework shows the connections and inter dependencies between the individual, the community and institutions, needed to be taken into account to better comprehend and study social cohesion in the future. For social cohesion to exist, individuals need to have motives to want to belong to a group/society, which stem from the cognitive beliefs (norms

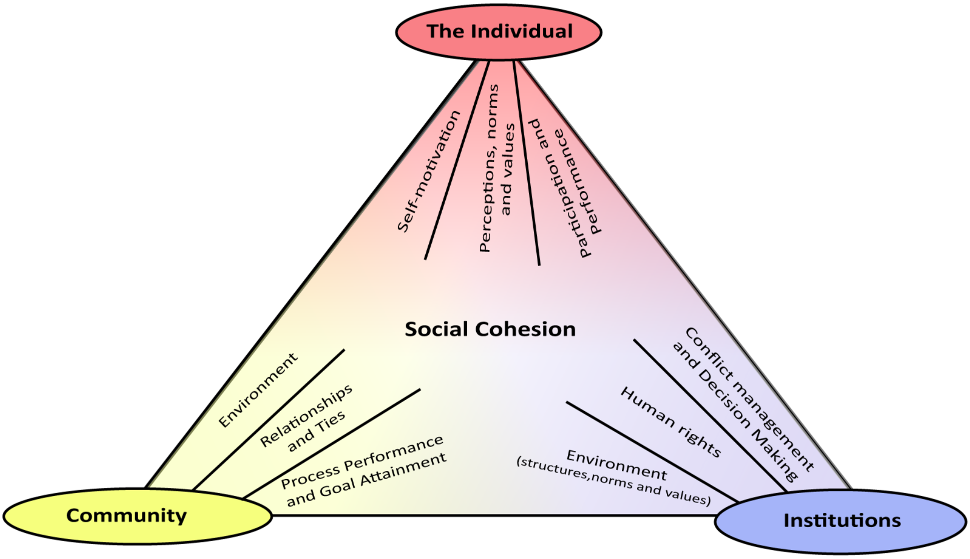


Figure 2.6: Framework to characterise social cohesion.

and values) they have. Perceptions of the environment and cognitive beliefs of an individual are directly linked to the informal and formal environments individuals experience and are able to experience. An individual can only feel in cohesion with the group and with the ability to participate and perform in it if the rest of the group provides with a proper environment with compatible norms and values. Equally, individuals can only take active part in a group if public laws, regulations, norms and values allow them to. If the person faces inequality, lack of representation and support of her position within a group or any deeply rooted conflict, then her personal drive to stay in the group is likely to fade away. It is therefore difficult to impact one of the three identified levels without ending up impacting one or more factors of any other level, and as such, the framework depicts this intersection.

Each factor shown in the framework, and belonging to a different level, is important to social cohesion and is inferred from the literature. At the level of the community, the factor of social environment is related to the social climate that a group has, and can be associated with the research done on for e.g. shared norms and values (Jeannotte, 2003), formal/informal control (Cartwright, 1951), friendship networks (Granovetter, 1977), pressures for conformity and caring (Janis, 1972), or civic society (Lockwood, 1999). The factor of relationships and ties (community) regards the capital that the members of a group get, and is linked to for e.g. social capital, trust (Larsen, 2013), reciprocal loyalties and solidarity (CoE, 2008), moral support (Durkheim, 1897), or value of rewards in the group (Homans, 1958). The third factor defined at the community level (process performance and goal attainment) regards the performance of the group and its common objectives, being thus linked to common goals and moral behaviours/norms (T. Parsons, 1991).

On the level of the individual, the mentioned factors (self-motivation, perceptions, norms and values, and participation and performance) are also linked to what is done so far. The factor of self-motivation relates to the reasons that lead the individual to be in a group, and links to the researched topics of for e.g. intimate face-to-face communication (Cooley, 1909), quality of intimate topics shared (J. P. Stokes, 1983), and recognition and legitimacy (Beauvais and Jenson, 2002). The factor of perceptions, norms and values regards the individual view the individual has over the group he is in and his own belief system, being thus pinned to the research done on for e.g. degree of like-dislike (A. J. Lott and Lott, 1966), and sense of belonging (CoE, 2008). The last factor on the level of the individual is participation and performance, regards the drive that the individual has to act and take responsibility in the group, and can be linked to the research done on for e.g. initiative (Lockwood, 1999), individual participation (Braaten, 1991), task competence (Festinger et al., 1950), and individual behaviour (Cartwright, 1951).

The last level, the one on institutions, defines the factors of conflict management and decision making, human rights, and environment (structures, norms and values). The factor of conflict management and decision making is considered as the governance of formal institutions in society, and can be associated with for e.g. social disorganisation or conflict (Cooley, 1909), and the reduction of inequalities and exclusion (CoE, 2008; Maxwell, 1996). The factor on human rights regards the agency, access and freedom of the individual while in a group/society, and research done in this direction is for e.g. voting (de Cooperación y Desarrollo Económico, 2011). Lastly, the factor of environment (structures, norms and values) regards the formal institutions and actors in society that are responsible for its upkeep, and can be coined to the research done on for e.g. social stability (T. Parsons, 1991), suicide rates (de Cooperación y Desarrollo Económico, 2011), trust and multiculturalism (Larsen, 2013), and civic society (Lockwood, 1999).

The factors included in each of the three levels propose measures to impact and measure cohesion, while being at the same time generic enough to be extended by other factors not currently mentioned for clarity purposes.

2.8. SOCIAL INTERACTION AS MAIN REQUIREMENT FOR COHESION

From the reported findings, this research argues that social interaction is a key requirement for the existence of social cohesion and its influencing. The presented volume of research on social cohesion shows that 3 different perspectives (*The Individual*, *Community*, and *Institutions*, section 2.7) are at play when comprehending societies and their levels of cohesion. These perspectives analyse cohesion at different levels (micro, meso, and macro), and reveal unique insights on the multiple social processes and actors at play.

Social interaction is a basic social exchange that supports complex interpersonal processes that are at the core of social cohesion. This exchange is considered by literature as happening at the micro-level, but it also argues that macro-level phenomena (like those reported influencing cohesion, like gender inequality) have an impact on micro-level processes (e.g. those related to emotions)[4] (Beard, 2014; Berger and Luckmann, 1991; Goffman et al., 1978; Hochschild, 1979). The pillars of the *Individual* and *Community* are associated with social interaction, for example, through the concept of "presentation of self", i.e. a performance with gestures and routines sometimes associated with social roles that individuals

[4]https://opentextbc.ca/introductiontosociology2ndedition/chapter/chapter-22-social-interaction/, Chapter 22: Social Interaction, last visited on December 23, 2020.

enact to influence others. These pillars are associated with interaction, as it can be part of the individuals' motivation to present themselves, which in turn influences the degrees of like-dislike between themselves and the group, promotes intimate face-to-face discussions, can strengthen relationships, and help individuals feel they belong to the group. Regarding the pillar of *Institutions*, formal institutions balance the behaviour of societies (e.g. its conflict levels, life satisfaction rates, reduction of inequalities and exclusion, and levels of trust and multiculturalism) by defining interaction structures throughout society (e.g. social integration). These interaction structures define factors such as democracy and law enforcement[5], which set and enforce rights that may or may not provide (for example) equality or integration to its citizens. As such, more complex social constructs such as cohesion exist and are influenced by social interaction.

2.8.1. Social Interaction: Definition and Characterisation

The definition used in this research for social interaction is ***"a social exchange between individuals"***, i.e. a dynamic and reciprocal exchange of social actions and reactions (LumenLearning, 2018). These exchanges are defined as "social processes" that contain several characteristics (e.g. purpose, repetition, structure, direction, and quality). Interaction can happen between oneself (intrapersonal), person to person, person to group, and between groups: the intrapersonal interaction is seen as having zero degree of social interaction (i.e. social isolation), whereas the other forms of social interaction (between 2 or more individuals/groups) display different degrees of intensity of social exchange (Bardis, 1979).

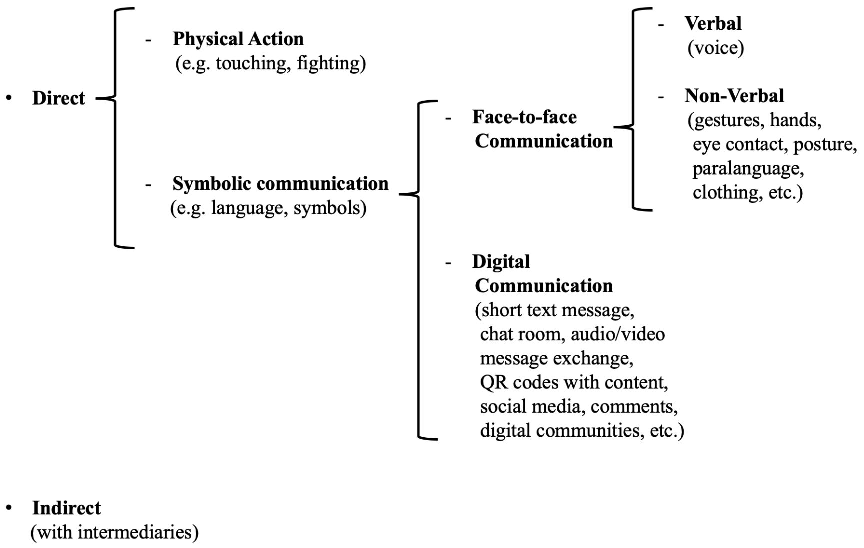


Figure 2.7: Types of Social Interaction.

The forms of social interaction are defined by literature in their nature, and in their types of exchanges. On the one hand, the nature of social interaction is defined by literature as

[5]https://www.jrf.org.uk/report/social-interactions-urban-public-places, Social interactions in urban public places, last visited on December 23, 2020.

focused (i.e. people with common goals, e.g. a group) and **unfocused** (i.e. no common goal, no familiar or common aspects, even during the process of interacting)[6] (Bardis, 1979; Coutts and Schneider, 1975; Mondada, 2009). On the other hand, literature argues that social interaction occurs through several types of exchanges (synthesis offered in figure 2.7) (Bardis, 1979; Goffman, 1961, 2008; LumenLearning, 2018). Often it regards face-to-face encounters, but it is also common for interaction to be remotely mediated through digital communication via technological artefacts (Gião et al., 2016; LumenLearning, 2018). Both befall the symbolic type of communication, as they communicate through symbols (either images/icons, or language as a structured exchange of symbols) that bear meaning to the interlocutors[7]. The symbolic type of communication, together with interaction through physical actions such as for e.g. fighting or touching, fall into the direct type of exchange: they can occur synchronous or asynchronously, use multiple channels (e.g. voice, or the form of speaking – paralanguage), but they occur directly between the interlocutors interacting[8]. Alternatively, interlocutors A and B can also interact through the involvement of intermediary people, which propagate the message from A to B. These fall within an indirect form of interaction, as direct interaction occurs between the intermediaries, but no direct interaction between A and B. Mode detailed coverage on social interaction and related concepts can be found in [6],[8],[9] (Bardis, 1979; Goffman, 1961, 2008).

2.8.2. Meaningful Social Interaction as a Way for Cohesion

To promote social cohesion, social interaction should be meaningful to those interacting (of Communities and Government, 2009). Local communities are cohesive when for example the people living in them know and respect their neighbours, are resilient towards negative forces external to the neighbourhood, and when people ideally form and maintain long lasting relationships irrespective of their backgrounds (Broadwood and Sugden, 2009; Lownsbrough and Beunderman, 2007; of Communities and Government, 2009). According to Blears (of Communities and Government, 2009), social interaction, when meaningful, can break down stereotypes and prejudice, empower people's agencies to act, has a positive impact on cohesion, emerges at people's own pace, and addresses conflict.

Given that the motivation for this research is on social cohesion and its betterment, then social interaction, a key requirement for the existence of social cohesion, should be meaningful. Given that the concept of meaning is complex, is influenced by numerous factors (e.g. religion), and is person-dependent (Putnam, 1975), *meaningful social interaction*, for the remainder of this research, is defined as **"an overall enjoyable experience for a player, and enjoyable or neutral for individuals involved in the gameplay"**.

[6] https://www.lifepersona.com/social-interaction-characteristics-and-main-types, Social interaction: Characteristics and Main Types, last visited on December 23, 2020.

[7] https://www.dictionary.com/browse/language, Language, last visited on December 23, 2020.

[8] https://www.sociologylearners.com/types-of-social-interaction/, Types of social interaction, last visited on December 23, 2020.

[9] http://studylecturenotes.com/social-interaction-definition-elements-types-forms/, Social interaction, Definition, Elements, Types & Forms, last visited on December 23, 2020.

2.9. Discussion and Summary

This chapter takes the motivation of promoting social cohesion in current societies, and zooms in on what it actually is. It presents a comprehensive survey of key studies on social cohesion, while highlighting different perspectives on social cohesion, what aspects they study, what findings have emerged from them, and how researchers have defined social cohesion over time. The way cohesion is consistently viewed reveals lack of consensus: as absence of conflict in groups, as a characteristic, group property, an individual drive for affiliation, strength of connections, and, among other things, as a process. It has been thoroughly studied over centuries, particularly through the perspective of theoretical and empirical studies, but also through the experimental studies that measure social cohesion through observation. Different approaches in experimental studies (to observe and measure, influence group cohesion or its resilience, and fostering social cohesion) also point to a plurality of ways to study social cohesion.

From the lessons learned, this work 1) updates current definitions of social cohesion with one that better matches the multicultural nature of current societies, 2) proposes a framework to help identify what impacts social cohesion and can thus be used to foster it, and 3) argues that social interaction is a major requirement to promote and influence cohesion. It argues that social interaction is a key exchange upon which more complex social constructs such as cohesion exist, in particular when interaction is meaningful to those interacting.

Lessons learned from this chapter start from the fact that social cohesion is a complex social construct in which specialists don't share consensus. It is clear that social cohesion is a complex and dense construct with multiple and interrelated phenomena influencing it, and that social interaction is a major requirement for it to exist and be fostered. As such, the rest of the thesis zooms in on **social interaction, and how it can be fostered in a meaningful way**.

3

DESIGNING LOCATION-BASED GAMES FOR MEANINGFUL SOCIAL INTERACTION: A LITERATURE REVIEW

I like when life feels playful.

Kerli

Previous chapter argues that social interaction is a basic social construct upon which other, more complex social phenomena can occur. This thesis takes therefore social interaction

This chapter is based on the published article: X. Fonseca, G. Slingerland, S. Lukosch, and F. Brazier, *Designing for Meaningful Social Interaction in Digital Serious Games*, Entertainment Computing, doi: https://doi.org/10.1016/j.entcom.2020.100385, 2020.
This chapter is based on the submitted article: X. Fonseca, S. Lukosch, H. Lukosch, and F. Brazier, *Requirements for Location-based Games for Social Interaction*, 2020 (Submitted to IEEE Transactions on Games, currently in review).
This chapter is based on the published article: X. Fonseca, S. Lukosch, and F. Brazier, *Fostering Social Interaction in Playful Cities*, in Interactivity, Game Creation, Design, Learning, and Innovation, vol. 265, Part of the Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering book series: pp. 286-295, Springer, 2019 (Fonseca et al., 2018a).
This chapter is based on the published article: G. Slingerland, X. Fonseca, S. Lukosch, and F. Brazier, *Location-based Challenges for Playful Neighbourhood Exploration*, Behaviour and Information Technology, doi: https://doi.org/10.1080/0144929X.2020.1829707, 2020.
This chapter is based on the submitted article: X. Fonseca, S. Lukosch, and F. Brazier, *Modular Software Architecture for Location-based Games Designed for Social Interaction in Public Space*, 2020 (Submitted to Entertainment Computing Journal, currently in review).

as the first requirement for the motivation of social cohesion and its promotion in local communities. Social interaction can occur in many different ways (figure 2.7), and this means that researchers have numerous opportunities and tools at their disposal to promote it.

Games are particularly suitable when social cohesion is the motivation, because they are versatile (i.e. can be used for a given serious purpose rather explicitly or not), all the while promoting playful behaviour. When the topic is social cohesion, the ability to promote playful behaviour is particularly appropriate: if certain local communities are argued to benefit from more cohesion and social togetherness, then it is likely that they display social issues (e.g. fragmentation, or lack of neighbourhood engagement) that social interaction could address in a playful way. To this end, this thesis explores games as a tool that is known to be able to promote some forms of social interaction. In particular, it looks at digital location-based games, for they display the ability to leverage on real positioning and the social context of players to provide a gameplay in the real neighbourhood, which is novel when compared to traditional games.

This chapter offers a literature review on existent knowledge about how to design location-based games for meaningful social interaction in public space. Firstly, it gives an overview on how playful approaches have been explored to encourage playful behaviour, engagement with the physical environment, and social interaction in urban environments. It looks at how technology, and smartphones in particular, have been explored to these purposes, and how location-based games have consistently been designed to offer in-situ gameplay that involves other people. Secondly, it delves into how location-based games have been built, to uncover what it is known so far: guidelines and requirements that can be used to design a game specifically for social interaction in public space, and existent theory on game characteristics leading to specific behaviour. Thirdly, it takes a technical perspective and researches what location-based games require from the systems' perspective to deliver the mentioned gameplay. At the end of this chapter, a discussion is held on the learnings and knowledge gaps found, so that this thesis can build upon them.

3.1. GAMES FOR SOCIAL INTERACTION IN PUBLIC SPACE

Over the past decades, technology has been turning cities around the world into smart urban environments, with initiatives encouraging playful behaviour and social interaction (Fonseca et al., 2021; Foth et al., 2011; Hirsch, 2011; Hornbek and Jensen, n.d.; Ling and Wong, 2011; Paulos et al., 2011). Location-based playful experiences are considered to be increasingly important for people to interact and explore their surroundings (Arango-López et al., 2017). These can be facilitated in many ways including (1) urban playgrounds without specific support by technology, (2) location-based media (devices with sensors such as smartphones that can detect location and other contextual information), or (3) custom-made technological installations (Yang and Liu, 2017).

An example of an urban playground is "A playful street" with multiple traditional playgrounds throughout several neighbourhoods of Dublin, Ireland, designed to promote open play behaviour for the young and elderly alike[1]. This initiative aimed at increasing playful behaviour and community formation, and, even though it created discrete events only, they

[1] https://www.aplayfulcity.com/, "A playful Street" project, last visited on December 23, 2020.

were successful at making children think about the future of their neighbourhood.

Examples of the use of location-based media include: 'Koppelkiek'[2] and 'Hello Lamp Post'[3]. 'Koppelkiek' fosters playful meetings and social interactions throughout public spaces in the neighbourhood in Utrecht, the Netherlands. Over the period of 3 weeks, the game increased engagement of citizens with their environment: players signed up to take and submit photos with other people from the neighbourhood, and it included people that would otherwise not see themselves as gamers. Every participant gave positive feedback about the impact of the game in their neighbourhood, and found the game nice. 'Hello Lamp Post' enables citizens to chat with chat bots (via a mobile app) attached to co-located objects (such as street furniture) in the public spaces of Bristol, United Kingdom. This game was played in several cities, and even though it is not clear what is the level of engagement it created, thousands of citizens engaged with these co-located objects.

Examples of custom-made technological installations include the 'Social Stairs' (Nijholt, 2017a), 'Shadowing'[4], 'Urbanimals'[5], 'ActiWait'[6], 'Dancing Light'[7], the 'Mood Cloud' (Kasapakis and Gavalas, 2015), and the 'Jokebox' (Fischer et al., 2007). 'Social Stairs' was designed to seduce citizens to have a playful musical stair experience entailing physical exertion in city subways, as opposed to using the escalator. The researchers found out that people's curiosity to find whether the stairs still produce sound is enough to make them take the stairs and change behaviour in their environment. 'Shadowing' records and augments shadows of citizens in specific locations in a neighbourhood (using infra-red cameras), creating a new synthesis of images to facilitate a new type of awareness of fellow passers-by's during a day. During its limited trial, this game recorded and played back the shadows of citizens that passed underneath, and made citizens substantially engage with these lights in playful manner. 'Urbanimals' uses similar technology to augment physical spaces with tailored-made animated images of animals, to explicitly encourage urban exploration through playful interaction with media artefacts placed throughout the city. This project reached several cities, and, in Bristol alone, over 26,000 people engaged in city discovery through interaction with these animated animals. 'ActiWait' and 'Dancing Light' are examples that use street furniture to create playful out-of-the-ordinary experiences to citizens and target fun: the former is a prototype that enabled people to play pong while waiting for the green light, and the latter is a campaign that showed real-time dance performances of people in a co-located dance booth. The Dancing Light, in particular, aimed at making people stop at the traffic red light, and it was substantially successful at that (81% more people stopped, and they enjoyed it). The 'Mood Cloud' (Kasapakis and Gavalas, 2015) and the 'Jokebox' (Fischer et al., 2007) mentioned above are two particular installations designed to support social interaction and a sense of community. The Mood Cloud is a physical installation that allows participants to express their individual mood and combines these inputs to a coloured display of the cur-

[2] https://whatsthehubbub.nl/projects/koppelkiek/, Koppelkiek, 'couple snapshot' in Dutch, last visited on December 23, 2020.

[3] http://www.hellolamppost.co.uk/, Hello Lamp Post, The playful city wide system, last visited on December 23, 2020.

[4] https://cargocollective.com/shadowing, "Shadowing" project, last visited on December 23, 2020.

[5] https://www.playablecity.com/projects/urbanimals/, "Urbanimals" project, last visited on December 23, 2020.

[6] http://urban-invention.com/, "ActiWait" project, last visited on December 23, 2020.

[7] https://www.youtube.com/watch?v=SB_0vRnkeOk, "The Dancing Traffic Light by smart", last visited on December 23, 2020.

rent moods of people in their direct environment. It was installed at the entry space of a multi-store college campus, and was successful at both making participants reflect on how much the mood cloud affects them, but also in influencing the mood of other individuals in a purposeful way. The Jokebox, on the other hand, is a box-based installation designed to require two passers-by to synchronise their behaviour to hear a joke, and aims at "ice-breaking" through physical coordination and eye-contact. This installation was designed to facilitate social interaction in public spaces, and researchers report that it was capable of that at two different levels. On the one hand, people stopped to understand how these boxes work together, which made people talk and even laugh together. On the other hand, people had more elaborate discussions on the reason why the Jokebox was in that location to begin with.

The presented examples show that location-based playful experiences can successfully trigger playful and engaging behaviour in in/outdoor social settings through technology and innovative design. However, many of these experiences are based on technology and installations, which, together with the often unique topology of the space, render the whole playful experience hardly scalable and reusable in other locations in a practical way. Digital location-based games (LBGs), running in mobile media such as smartphones, can address this, and be designed to scale and adapt to environments and their singularities (Slingerland, Fonseca, et al., 2020). They can be specifically designed to support citizen engagement with their environment, in order to 1) gain information about specific locations and objects (Peitz et al., 2007) in a neighbourhood (such as objects with a medieval history (Ballagas et al., 2007)), 2) support activities at specific locations (such as prolonged walking (Pyae et al., 2017)), and 3) increase communication and social interaction during game play (Hodson, 2012). LBGs merge digital game play with the physical world around a player's real location[8] (Paavilainen et al., 2009), and can make players work together or play against each other, in a distributed or co-located manner in outdoor public space (Brazier and Nevejan, 2014; Wagner-Greene et al., 2017), through mobile technology with features such as augmented reality (AR) and networking capabilities (Slingerland et al., 2018). Examples of such games, both prototype games for research and entertainment ones, are Pokemon GO (Clark and Clark, 2016), Google Ingress (Hodson, 2012), BotFighters (Sotamaa, 2002), Shadow Cities[9], Feeding Yoshi[10], Insectopia (Peitz et al., 2007), Field Trip[11], Endgame: Proving Ground (Pyae et al., 2017), Mythical: The Mobile Awakening (Korhonen et al., 2008), Day of the Figurines (Flintham et al., 2007), Mogi (later called Geocaching)[12], and CityConqueror (Papangelis et al., 2017).

BotFighters, *Shadow Cities*, *Field Trip*, *EndGame Proving Ground*, *Pokemon GO*, *Feeding Yoshi*, *Google Ingress*, and *Mogi/Geocaching*, are commercial games that motivate players to walk around the real environment and collect digital and real items, explore individually or in a group, compete with other players in battles for the ownership of items such as

[8] These games are mainly supported by smartphones and mobile devices, because they are networked, full of sensors (predominantly GPS and Wi-Fi), widespread, and easily accessible (Crabtree et al., 2007; Korhonen et al., 2008) .

[9] https://www.giantbomb.com/shadow-cities/3030-35591/, Shadow Cities, last visited on December 23, 2020.

[10] http://www.freewarepocketpc.net/ppc-download-feeding-yoshi-v1-2.html, Feeding Yoshi v1.2, last visited on December 23, 2020.

[11] https://itunes.apple.com/us/app/field-trip/id567841460?mt=8, Field Trip, last visited on December 23, 2020.

[12] https://www.geocaching.com/play, Geocaching, last visited on December 23, 2020.

Pokemons or landmarks in the real world, and collaborate with other people in unique digital item exchanges or team formation. On the research side, *Insectopia* is a prototype game that allows players to digitally compete for the collection of the biggest number of insects. It advocates for social interaction and nudges players into sending insects to any other player in the game at any time. *Mythical: The Mobile Awakening* is a mobile game designed for players to play together as wizards in a parallel reality. It exploits asynchronous game play to allow players' avatars to interact with one another during encounters, even though the players are not online at the same time. *Day of the Figurines* is a physical board game in which players build a shared narrative of a digital city in a cooperative way. During the players' daily routines and throughout several weeks, they send text messages to interrupt the stories of other players and advance the narrative of the game. Lastly, *CityConqueror* is a game that promotes competition through beating other players in the ownership of digital territory layered on top of the real environment. The researchers of this game explicitly chose digital mechanisms of interaction such as friendly fire and the attack of a region by fellow team members to maximise digital interaction between players (Papangelis et al., 2017).

These examples show that numerous attempts have been made at creating LBGs capable of triggering dynamics of play that invite citizens to engage with their surrounding environment and have social play. However, by analysing the literature and information release online, often it is seen that it is not known how these games were put together. Regarding *Koppelkiek*, the researchers reported online[2] that the process of game development started off with a fruitful in-house idea generation stage, followed by quick play tests with people on the streets of Utrecht. In parallel to those play tests, they did a field study to discover useful information to be later added on to the final concept of the game, which was again resultant from in-house choices. *In Mythical: The Mobile Awakening*, the researchers chose to develop a game to elicit an initial set of design guidelines for pervasive mobile games, and used game elements such as contextual information, asynchronous game play, and predefined interval updates (Korhonen et al., 2008). The description of the design process of this game clearly shows that the requirements used for this game idea stem from the researcher's choices (Korhonen et al., 2008). For *Day of the Figurines*, the requirements and why those and not others were chosen are unknown. Again, the researchers' reasoning suggests that the design decisions that were made came from them (e.g. "to ensure as many players as possible would be able to play the game using their own mobile phones, it was decided early on ... to base the game on SMS text messaging" (Flintham et al., 2007)). *CityConqueror* has design choices made by the authors (e.g. no story line such as in Pokemon GO, a real map of the city, and the turn-based game mechanic) that are simply justified with the rationale "as it is popular in ...", and do not have a better motive to support them. The *Hello Lamp* is a playful initiative where it is not clear how it was conceived with regard to requirements. When it comes to commercial games, it is even more difficult to know what the processes used were and to find the justification as to why certain requirements were used.

When it comes to requirements for social interaction, each of the presented games seems to be an experiment of the designers to see what works or not, after being designed by a set of choices that came from the designers themselves and play-tested later on. As a result, it is not clear whether the presented games were developed explicitly for social interaction, or whether triggered interaction was just a by-product of games developed for other purposes. This poses as a knowledge gap, for it is not known what works for LBGs specifically for the promotion of social interaction in public space, and how it links to the players. Next section looks at understanding how such games can be put together, from the perspectives of gameplay requirements, game components that might be known to trigger social interaction, and how practitioners have been building LBGs from a systems' perspective.

3.2. How to Design for Meaningful Social Interaction in Public Space

The following sub-sub-chapters delve into specific literature on how LBGs for the identified purpose can be put together, by: 1) analysing if there are heuristics, guidelines, design patterns, or requirements that lead to successful LBGs for social interaction, 2) researching whether there is knowledge on designing games for specific behaviour elicitation or not (e.g. meaningful interaction), and 3) investigating how to put LBGs together from the systems' architecture, in such a way to make such games trigger social interaction in public space, and support meaningful experiences.

3.2.1. Analysis of guidelines and requirements specific to social interaction

To the best of our knowledge, there are no gameplay requirements specific to location-based games fostering social interaction in public space. Game design practitioners in gaming companies do a non-user-centred requirements elicitation phase during the early-stages of game conceptualisation, which makes it tacit knowledge not available to the "outer world" (Daneva, 2014). The requirements that are documented are scattered across different types of games, such as for pervasive games in general (Eriksson, 2005; Ermi and Mäyrä, 2005; Korhonen et al., 2008), serious games (Duin and Thoben, 2011; Gennari et al., 2019; Mascio et al., 2013; D. Parsons et al., 2006), movement-based exergames (Consolvo et al., 2006; Florian 'Floyd' Mueller and Vetere, 2014; K. M. Gerling et al., 2010; K. Gerling et al., 2012; Isbister and Mueller, 2015; F. '. Mueller et al., 2017; F. Mueller et al., 2010; J. Yim and Graham, 2007), online gaming sites (Choi and Kim, 2004), electronic computer games (Bostan and Ogut, 2011; Miesenberger et al., 2008; Straker et al., 2014), mobile multiplayer (AR) games (Chilufya, 2014; Ganapathy, 2013; Korhonen and Koivisto, 2007; Wetzel et al., 2008), massive multiplayer online games (Daneva, 2017), non-digital multiplayer games (Zagal et al., 2000), and AR (augmented reality) indoor-based games (Al Mahmud et al., 2010; Hauge et al., 2019; Hinske et al., 2008; Nilsen, 2006). While this shows an existent volume of research on guidelines and requirements on how digital games should be, these are not aiming specifically for the promotion of social interaction. These guidelines, requirements, and heuristics are offered mostly to children and the elderly, cover quality requirements for emotions, exertion, motivation, engagement and awareness levels, behaviour education, presence, social adaptability, accessibility, inter-generational and indoor game plays both with computers, toys and table tops, and they also include recommendations specific to user experience for impaired users, mobile learning experiences, and user-game interaction.

Nonetheless, this existent literature is helpful in understanding how the different types of games have been exploring social interaction as a sub-component of serious games. In (Zagal et al., 2000), the authors consider social interaction as purposeful bilateral communication that is either natural (spontaneous) or stimulated (necessary to the game), and that these can either be triggered by the game (e.g. via competition and cooperation that can be synchronous or not), or in the existence of meta-gaming (side-games in parallel to the actual game). Other researchers strengthen this point, which argue that communication outside the game world is key for a gameplay happening in public space, both in line with meta-gaming (Korhonen and Koivisto, 2007) and natural face-to-face communication (Korhonen et al., 2008). Even though digital interaction is still the most common form of interaction advocated across literature (D. Parsons et al., 2006), research regarding a balanced gameplay between a pure virtual and real world game play experience, with the use of multiple communication channels, appears multiple times (Eriksson, 2005; Nilsen, 2006; Wetzel et al., 2008). This suggests that social interaction is best triggered when involving play settings allowing for the full range of exchanges between individuals (players and non-players alike) in a balanced way (Al Mahmud et al., 2010; Straker et al., 2014; Valente et al., 2017). Involving people from different generations can contribute to a richer and more unique social experience (Chilufya, 2014; Grimaldo et al., 2014), and the employment of tangible objects bear the power of bringing people to the same space and set novel ways of interaction (Hinske et al., 2008). Exceptions exist, however, when players are afflicted with an impairment, which can display an unwillingness to play with other people (Mascio et al., 2013).

3

Most of the presented design recommendations stem either from literature (Chilufya, 2014; Eriksson, 2005; Ganapathy, 2013; Grimaldo et al., 2014; Isbister and Mueller, 2015; Miesenberger et al., 2008; Nilsen, 2006; D. Parsons et al., 2006; Straker et al., 2014; Valente et al., 2017; J. Yim and Graham, 2007; Zagal et al., 2000), game analyses (Bostan and Ogut, 2011; Korhonen and Koivisto, 2007; Korhonen et al., 2008; Mandryk et al., 2014), or the making experience of practitioners in the field (Consolvo et al., 2006; K. Gerling et al., 2012; Hinske et al., 2008; Isbister and Mueller, 2015; Wetzel et al., 2008). A study was found as exception, i.e. as proposing user-centred guidelines with some connection to social interaction. Choi et al. (Choi and Kim, 2004) created a large survey study to understand which features players thought were responsible for optimal engagement in online games. Even though digital interaction is covered in their guidelines (e.g. chatting functions and a user id for communication), these focus on online user engagement and completely leave offline-based forms of interaction unexploited. Such insights are valuable when aiming at social interaction in public space via digital games. However, given that the vast majority are not player-centric (i.e. do not come from the players) but play-centric (i.e. game prototypes are firstly created by companies, then users are involved) (Daneva, 2014), these do not shed light into which gaming activities player prefer having in their neighbourhood most. This is a knowledge gap, for it is not known what other gaming activities could be used to expose players to the public space of their neighbourhood and the people in it.

3.2.2. Game components leading to specific player behaviour

Games have shown to be able to invite citizens to engage with the public space and others in their own surroundings (Fonseca et al., 2018a), by fostering play and participation of citizens, nurturing bonding and social relations (Ball et al., 2010; Fonseca et al., 2018b; Galinsky et al., 2005; Peters et al., 2010), and being capable of inciting behavioural change, regardless of the domain of application or goal (e.g. entertainment, competition, or education) (Egenfeldt-Nielsen et al., 2019). Players can become seriously engaged in game play and can even go as far as having a sensation of "flow" and detachment from their reality (E. Brown and Cairns, 2004; Egenfeldt-Nielsen et al., 2019; Fitz-Walter, 2015). Despite attempts to understand the effects of individual game elements (Fitz-Walter, 2015; Malone, 1981), through theories and methods of analysis of games (Boyle et al., 2011; Fitz-Walter, 2015; Harteveld, 2011; Hunicke et al., 2004; Menestrina, 2017), it is, as yet, still unclear which design choices lead to which behaviour/behavioural change (Egenfeldt-Nielsen et al., 2019; Reer and Krämer, 2019). There is, for example, no agreement on whether a game with specific characteristics (e.g. a violent game) leads to specific behaviour (e.g. violent behaviour) (Anderson, 2004; Barker and Petley, 2013; Egenfeldt-Nielsen et al., 2019; of Pediatrics et al., 2009; Zendle et al., 2018).

Motivation and behavioural change has shown to be achieved via numerous combinations of game elements (e.g. graphics, rules, a storyline, or levels) (Deterding et al., 2011), and via more complex game mechanics and dynamics that are only observable during game play mediated by the game (Hunicke et al., 2004). However, researchers are still actively trying to understand the strategic applicability, usefulness, and impact of specific design choices on games, in particular serious games, as these can have a positive and negative effect on players (Fitz-Walter, 2015). This knowledge can enable a greater understanding of individuals, their relationships, their social networks, the environment in which they live, and help designers design artefacts that adhere to citizen's preferences, desires, and needs (Fonseca, Lukosch, Lukosch, and Brazier, 2020; Foth et al., 2011). Researchers have been in pursuit of such understanding by focusing on highly specific case studies, and then trying to generalise their findings to serious games. Such knowledge includes the values that designers should have in mind when designing games for purpose (Arrasvuori et al., 2010; Blythe and Monk, 2018; de Freitas and Routledge, 2013; Fitz-Walter, 2015; Liu et al., 2011; Malone, 1981; Preece et al., 2015), the applicability of games in specific domains (Cheok et al., 2014; Egenfeldt-Nielsen et al., 2019; Nijholt, 2017b), and even design guidelines to help researchers design and develop serious games for specific domains that are most often successful (K. M. Gerling et al., 2010; Kroeze and Olivier, 2012; Tsekleves et al., 2016). Regarding the values that are important for serious games and gamified serious tools, these go from traditional usability goals such as efficiency, learnability, good utility, and ease of use (Fitz-Walter, 2015), to values such as fun (Malone, 1981), play and playful experiences (Arrasvuori et al., 2010; Blythe and Monk, 2018), motivation (Liu et al., 2011), emotional fulfilment (Preece et al., 2015), and learning (de Freitas and Routledge, 2013). These values are essential for responsible design, in particular when designing for meaningful social interaction for civic engagement.

Guidelines that are specific to meaningful social interaction in public spaces, to the best of our knowledge, have yet to be formulated. As indicated above (sub-chapter 3.2.1), the vast majority of the guidelines and requirements implemented as characteristics of LBGs (i.e. game elements, mechanics, and dynamics) are neither specific to social interaction, nor player-centred. This is a problem: designing for meaningful social interaction requires consideration of player preferences, needs and requirements to support interaction that is both desired and meaningful to those interacting, and that includes playful behaviour with the environment and others (Fonseca et al., 2018a, 2018b; Fonseca, Lukosch, Lukosch, and Brazier, 2020; Fonseca et al., 2017; Slingerland, Fonseca, et al., 2020). Questions that relate to these preferences, needs and requirements include: Do players prefer dynamics of verbal communication and close physical encounters with other people? Or do they prefer to leave digital messages in the real environment? Should there be collaboration, competition, points, easy challenges, and/or challenging riddles to crack? When does social interaction become meaningful to players? This is a knowledge gap, for it is not known which game components, when combined, lead players to engage openly with passers-by in their own neighbourhood, and invite them to meaningfully interact.

3.2.3. Location-based games and their systems' architecture

So far, this thesis discusses the knowledge gap on how to build LBGs for meaningful social interaction in public space, by analysing if there are heuristics, guidelines, design patterns, or requirements that lead to successful LBGs for social interaction, and 2) researching whether there is knowledge on designing games for specific behaviour elicitation or not (e.g. meaningful interaction). In this sub-sub-chapter, it argues as well that it is important to investigate how to put LBGs together from the systems' perspective, in such a way to make such games trigger social interaction in public space, and support meaningful experiences.

LBGs are unique from the systems' perspective, when compared to traditional games, but research on software architectures for LBGs show a lack of consensus at various levels on what these should offer. A few architectural components are proposed consistently, such as the mobile device (and the application it runs), the servers supporting the game, and content management systems with authoring capabilities (Kasapakis and Gavalas, 2015; Nolêto et al., 2015; Paelke et al., 2008; Söbke and Streicher, 2016). Most of the components proposed, however, are either 1) unique when compared to components other designers and developers propose, 2) use distinct names for components that are nonetheless similar in functionalities, or 3) do not refer to the system's architecture.

With regard to different components and names being used to describe similar functionalities, examples of components include: a content management system and authoring tools (Söbke and Streicher, 2016), game content generation (Kasapakis and Gavalas, 2015), map-based authoring (Paelke et al., 2008), or simply editor (Nolêto et al., 2015). All four focus on management of the content provided by a game, and even the ability to author such content. However, these names leave room for interpretation on the exact functionality these components provide: is the content to be linked directly to a map and the surroundings of the player; is it superimposed on a map; is it some other type of information provided to players; or does it refer to game art? Examples of key components that have been proposed as such, but are not necessarily key to LBGs in general include client-server-middleware handling request management (Söbke and Streicher, 2016), and components to support multiple external service providers (Nolêto et al., 2015; Paelke et al., 2008). Such lack of consensus leads to confusion on what is actually needed in an LBG at large.

Several articles on LBGs focus on guidance but not from the system's perspective. These include 1) design frameworks, 2) design patterns, 3) game engines, and 4) functionality that is key to application design, not the system itself . Frameworks and patterns (1 and 2) guide game creators in selecting individual application related functionality (Björk and Holopainen, 2006) and knowing how to combine them to solve a particular problem (Bjork and Holopainen, 2004; Dormann et al., 2013; Reuter et al., 2014). With respect to game engines (3) the guidance provided is at the level of programming frameworks and software environments (Cowan and Kapralos, 2014, 2017; Craighead et al., 2008; Kasapakis and Gavalas, 2015; McShaffry, 2014; Siakavaras et al., 2018), on the smartphone. With regard to functionality that is key to application design (4), several articles refer to functionality such as storytelling (Naliuka et al., 2010), and design and play setups (Avouris and Yiannoutsou, 2012), that address the design of the application itself and not the overall software architecture and its components.

As a result descriptions of LBGs are not consistent on focus or terminology. With respect to the mobile device, for example, recent work either does not refer to the functionality needed/provided (Söbke and Streicher, 2016), or it refers to functionality to which other researchers do not refer (e.g. an interface, content, middleware, and positioning technology in (Paelke et al., 2008), rendering, data exchange, and game input in (Nolêto et al., 2015), or simply GPS and internet in (Jacob and Coelho, 2011)). Descriptions of LBGs differ significantly with respect to the description of the servers involved: they can be centralised or dedicated (Kasapakis and Gavalas, 2015), linked over a 'networking layer' (Nolêto et al., 2015; Paelke et al., 2008), and/or provide multiple services (e.g. management of missions, mechanics, messages, components, and players (Jacob and Coelho, 2011; Nolêto et al., 2015; Paelke et al., 2008)).

These different approaches to LBGs contribute to the misinformation and lack of guidance, for the multitude of approaches and different perspectives, different names used for similar functionalities, and unique functionality not stressed elsewhere, conceal what should really be offered in such games. This creates a clear need for a software architecture that can guide game designers and developers in the creation of future LBGs. Such an architecture can bear the ability to provide a high-level perspective of the design of LBGs from a system's perspective, and distinguish key components for key functionality. It can also further the understanding of LBGs by not only contributing with knowledge on what is required and why, but also serve as catalyst for other software architectures to emerge that can provide guidance on LBGs developed for different purposes (Fonseca, Lukosch, and Brazier, 2020a).

3.3. Discussion and Summary

This chapter shows that there are multiple ways to promote playful behaviour involving interaction in urban environments, some involving more technology than others. Smartphones are an easily accessible medium that is already owned by most citizens, which render them attractive to explore neighbourhoods. Location-based games (LBGs) have been designed to invite citizens to engage with their neighbourhood and the people in it. Nonetheless, we learned that it is not clear how such LBGs came to be. By looking at actual LBGs, we learned that the gameplay requirements are either not known, or that they came mostly from game designers. We also learned that this informational gap is deepened by the inexistence of design guidelines that are appropriate and specific to social interaction in public space. Those that exist are 1) not specific to social interaction in public space (or only cover digital communication), and 2) are based on play-centred approaches and not user-centred. From the literature, we also know that there are no known game characteristics (i.e. elements, mechanics, or dynamics) associated specifically to social interaction, thus showing a gap in the existent knowledge on how to specifically trigger behaviour leading to meaningful social interaction. Lastly, literature on the systems perspective of LBGs reveals that there is no consensus on what system components are essential for this type of games to work. Different names are used for the same components, researchers stress the importance of different components that are unique (not appearing in other studies), which reveals the gap of clarity: research on the topic benefit from a greater understanding on what is essential for such games to successfully promote and sustain interaction.

Literature shows multiple research gaps, presented in this chapter, which show it is unclear how to design LBGs for meaningful social interaction in public space. It is not known which game components, when combined, lead players to engage openly with passers-by in their own neighbourhood, and invite them to meaningfully interact. Existent LBGs are mostly not based on users' requirements, and this thesis argues this to be a problem, for social interaction to be meaningful to players, it needs to be tailored to the ways they prefer interacting, and the locations they desire. This thesis argues that, for such gameplay to successfully occur, it is required consideration for players' preferences, needs and requirements to support interaction that is both desired and meaningful to those interacting, and that includes playful behaviour that is tailored to players. Insights into the ways that users want to interact can further advance our current understanding on how to appropriately design for social interaction, which gameplay should be explored to captivate players, and how to build LBGs that could potentially lead to meaningful social exchanges.

This thesis also argues that, for such LBGs to be successful at sustaining social interaction in public space, a clearer technical perspective on how to do it needs to exist. Designers and developers of games have no guidance on how to create such games from the perspective of system design, and do not share a consensus on which components LBGs in general should implement. This thesis argues that LBGs aiming at fostering interaction in public space have system requirements that are distinct from traditional games, that requirements for social interaction make these LBGs demand a specific systems architecture that is capable of sustaining the desired game play, and that the current understanding should be enhanced, on which key architectural components must go into such games. These are knowledge gaps hindering practitioners in the creation of future LBGs for social interaction in public space that are tailored to the preferences, needs and desires of users.

4

Understanding User Requirements

This chapter focuses on understanding the requirements users have for LBGs for social interaction in public space, and what works with them. It was identified a gap in the previous chapter, where LBGs are mostly not based on users' requirements, and how they are usually involved only at later stages of game development. This is a problem, given that for social interaction to be meaningful to players it needs to be tailored to the ways the users prefer interacting. This chapter presents a series of 4 case studies aimed at exploring such requirements: an iterative requirements design approach is followed to probe different users (adolescents and adults), in different settings (Rotterdam, and The Hague), and with different tools (game prototypes, and user-centred design techniques). The first case study aims at comprehending the social context of adolescents in challenging neighbourhoods, and to explore requirements at the gameplay level. This is done by using low-tech brainstorming techniques to allow users to inform on their preferences, desires and needs. Second and third case studies aim at exploring such information (gameplay requirements) to further understand what users (adults) want to see in a game of this type in regard to content. In both the second and third case studies an iterative approach in designing and developing a game prototype was followed, so that the participants of the multiple workshops could be probed on what works for them in a playful way. The last case study explores if what adolescents want to play goes in line with the lessons learned from adults in the 2nd and 3rd case studies, and aims at having a better understanding of both 1) specific gaming activities that appeal to this target group, and 2) the theoretical relationship that the types of activities desired by users have with the interaction they foster. This is done by walking with the adolescents around their neighbourhood and by using low-tech equipment to support the creative process and co-design game challenges, which, at a later stage, are analysed on the nature and types of interaction they can trigger. This chapter thus researches how and what users want to play in their own neighbourhood.

4.1. CASE STUDY 1: USER REQUIREMENTS FROM ADOLESCENTS IN ROTTERDAM

Your soul is infinitely creative. It is alive and expansive in nature.
It is curious and playful, changing with the tides of time.

Debbie Ford

4

This research has the main goal of fostering social interaction, as a way to positively influence social cohesion (of Communities and Government, 2009). Literature on social cohesion argues that there are three types of actors that should be taken into account to impact social cohesion best (the individual, the community, and formal institutions) (Fonseca et al., 2018b), and as such, this research involves all three types. It started off by involving formal institutions playing a role in the lives of the citizens of Rotterdam, NL, (the municipality of Rotterdam and the Dutch Police), which pointed out to local communities in Feijenoord, a neighbourhood in the south of Rotterdam, that could benefit from a positive approach towards social cohesion. From the communities' perspective, a cultural think tank and two different secondary schools were involved, given their knowledge and strong connection to individuals from the neighbourhoods being studied. Lastly, the individuals involved are living in the neighbourhoods indicated by the municipality, and in close connection with the selected schools. This research learned from these actors that it is important to have people interacting again on the streets and talking to each other. They argue that there are neighbourhoods (particularly in the south of Rotterdam) that have more than 50% of their inhabitants being immigrants, that there is a substantial expression of crime and social undermining (Duffy et al., 2002), and that a "smart" way of addressing the situation would be to have a "positive" approach for such reality.

Their feedback resonates with public statistics of the city. In 2019, Rotterdam is a city that contains an estimated number of 644,527 people with 50.3% is of foreign ethnicity[1] (figure 4.1), and it ranks as the top city in the Netherlands with the highest rate of reported crime incidents[2]. Feijenoord is even more diverse with regard to ethnicities, with less than 40% being native Dutch, while ranking low in the social and safety quality indexes that regard for e.g. contact with local residents, crime and nuisance[3]. The mentioned actors argue

This case study is based on the submitted article: X. Fonseca, S. Lukosch, H. Lukosch, and F. Brazier, *Requirements for Location-based Games for Social Interaction*, 2020 (Submitted to IEEE Transactions on Games, currently in review).

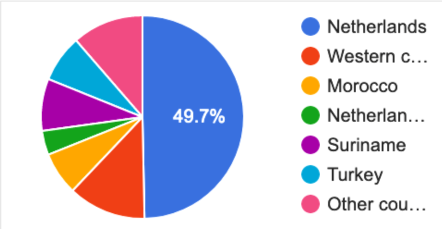
This case study is based on the published article: X. Fonseca, S. Lukosch, H. Lukosch, S. Tiemersma, and F. Brazier, *Requirements and Game Ideas for Social Interaction in Mobile Outdoor Games*, CHI PLAY '17 Extended Abstracts, Publication of the Annual Symposium on Computer-Human Interaction in Play, pp. 331 - 337, 2017.

[1] https://www.citypopulation.de/php/netherlands-admin.php?adm2id=0599, Provinces and municipalities in the boundaries of January 2019, last visited on December 23, 2020.

[2] https://www.numbeo.com/crime/country_result.jsp?country=Netherlands, Crime in the Netherlands, last visited on December 23, 2020.

[3] https://wijkprofiel.rotterdam.nl/nl/2018/rotterdam/feijenoord, Feijenoord, last visited on December 23, 2020.

that a serious game targeting young adolescents, if engaging enough, could trigger a cascading interest strong enough to reach their parents and fellow neighbours in the area, which they hope would bring more people to the streets and enhance security overall. The selected target group is thus adolescents from 12-16 years of age, not only because games have characteristics that appeal to this target group (Prensky, 2001), but also because older ages (17 onwards) are likely to start changing their lives substantially (including the neighbourhood they live in)[4], and, on average, 69% of European adolescents use smartphones (Docomo, 2014).



Birth Country of Parents (E 2017)	
Netherlands	315,300
Western country	78,789
Morocco	43,555
Netherlands Antilles	24,475
Suriname	52,579
Turkey	47,772
Other country	72,190

Figure 4.1: Birth Country of Citizens in Rotterdam[5].

4.1.1. RESEARCH DESIGN FOR REQUIREMENTS ELICITATION

The methodology of research deployed in this study is research through design (RtD) (Zimmerman et al., 2007), and cooperative inquiry (Fails et al., 2013; Nesset and Large, 2004). RtD uses methods and processes of design practice to develop new knowledge (Zimmerman and Forlizzi, 2014). The knowledge developed in this study is knowledge of the preferences, needs and desires adolescents have with respect to the use of a location-based game designed for interaction with other citizens in their neighbourhood (which are translated into requirements). This knowledge comes from the adolescents themselves, the future players of such games, and as such involves cooperative inquiry, that draws from the design methods of participatory design and contextual inquiry (Fails et al., 2013; Schuler and Namioka, 1993).

To elicit preferences, needs and desires of adolescents, and understand the way they prefer to interact socially in their own neighbourhood, adolescents were involved as informants in a set of structured workshops. The role of informant is one of several that end-users can be given in the making and shaping of digital technology, and each role (as users, testers, informants, design partners, or protagonists) warrants different degrees of involvement (Kinnula and Iivari, 2019). The degrees and depth of involvement in participation, the several dimensions that cut across them, the multiple methods and techniques of designing with

[4] http://www.amchp.org/programsandtopics/AdolescentHealth/projects/Documents/SAHRC%20AYADevelopment%20LateAdolescentYoungAdulthood.pdf, Late adolescence, last visited on December 23, 2020.

[5] https://www.citypopulation.de/php/netherlands-admin.php?adm2id=0599, Provinces and municipalities in the boundaries of January 2019, last visited on December 23, 2020.

4

participants, and the numerous philosophies upon which these are built, can be found in (Benford et al., 2000; Druin, 2002; Fails et al., 2013; Guha et al., 2004; Hourcade, 2008; Iversen et al., 2017; Nesset and Large, 2004).

For this study two game design workshops were organised at two different schools in Feijenoord to increase understanding of adolescents' preferences with respect to 1) the types of games they would like to play in their neighbourhood, 2) co-players - with whom they would prefer to play, and 3) locations within their neighbourhood. The structure of both workshops is based on the Triadic Game Design (TGD) approach, following a design philosophy that aims to balance the three elements of *reality* (of players), *meaning* (goal for the game), and *play* (the game play) (Harteveld, 2011). The gamification techniques used during the workshops included game elements and dynamics of collaboration, competition, points, prizes at the end, and a commercial card deck toolkit to trigger adolescents' creativity.

The selection of the participants for the two workshops was handled by the schools themselves, with no influence from the researchers. and no restrictions (e.g. gender or ethnicity) other than their age and the neighbourhood. The two schools announced the workshops within their schools as an event for students living locally (in the area of Feijenoord) in the target group age of which they could volunteer, and contacted adolescents personally. To those interested, consent forms for parent approval for both participation and data collection were distributed (and collected) by the schools. The schools were the "Rotterdams Vakcollege De Hef" (RVC De Hef), and the "Scheepvaart en Transport College" (STC).

All participants were told beforehand that they will be asked to think of a game that (1) is fun, (2) is meant to be played in your neighbourhood, (3) with your smartphone, and (4) involving everyone in it, providing an initial frame of reference.

Workshop structure

The structure of both workshops followed a modified version of the TGD approach, including all three of its elements, reality, meaning, and play (Harteveld, 2011). The world of reality describes the reality of the players, i.e. the social situation in which gameplay occurs. It contains information about the actors responsible for either the problem or its solution/mitigation, and the relationships between them. The world of meaning is intertwined with the purpose of the game, i.e. the creation of value (in this case, social interaction that is meaningful to players). This value proposal is the value that the game brings beyond the game itself, or the purpose intended for the game to achieve. The world of play is the medium used to deliver such value, i.e. the tools, elements and mechanisms used to land the desired game play. The game can have different genres (game characteristics), scenarios, and technology used for it to be played. These three worlds were defined for the workshops with the adolescents as: the characterisation of the neighbourhood (adolescents' reality), brainstorming on game requirements (the meaning to give to the game), and the design of a game (what and how to play).

The structure of the workshops focuses on the three dimensions of TGD (figure 4.2). Each of the three major worlds is characterized by specific questions previously prepared by the researchers and stem from TGD. For reality, the characterization of the neighbourhood, the questions are:

1. "Identify your neighbourhood by indicating the area on a map of Rotterdam"

2. "Characterise the neighbourhood, and the things and people that play a role in your neighbourhood (people, organisations, artefacts, phenomena, etc.)"

3. "Draw a picture showing the relations between the identified people/objects"

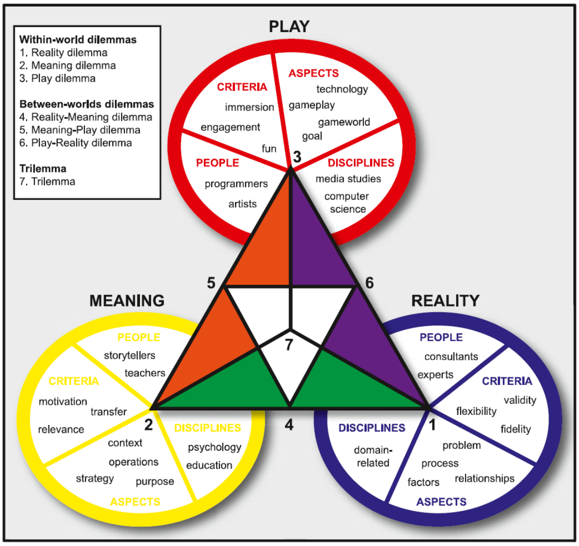


Figure 4.2: Triadic Game Design philosophy (Harteveld, 2011).

For the brainstorming of the game requirements, the following questions are answered in smaller groups:

1. "Figure activities for you to do (or could do) with other people"

2. "Brainstorm activities that would lead to the joint game activities"

3. "Identify the major players of the game (who do you think should be part of the game, even if not directly playing the game)"

4. "Where (major locations), when (the game is to be played), and how (with which devices) will the game be played?"

For the design of a game, the workshop follows a gamified approach through a commercial card deck[6], to help participants generate game ideas by proposing game mechanics, social mechanics, player motivators, and victory conditions (Fonseca et al., 2017). This approach follows the technique "bags of stuff" from the cooperative inquiry, to create multiple solutions (Fails et al., 2013). The card deck supports a process of 5 steps: (1) definition of title, topic, and audience of a game, (2) definition of motivations to play the game, (3) definition of victory conditions, (4) setup of the rules of play, and (5) making the game social

[6] http://gamification.playgen.com/, AddingPlay, powered by PlayGen, last visited on December 23, 2020.

(how players can interact with others). Adolescents draw a number of cards (the number differs per step) that, in turn, are used to create the game they have in mind. These cards act as creativity triggers that guide the adolescents by incrementally exploring how their idea(s) translate to their own world of play. The gamified card deck was translated to Dutch for the target group, and was chosen because it offers a playful focus on game design in a simpler and easier to learn and use way (Sisarica, 2015) when compared to other tools in standard practice for the brainstorming of game mechanics (de Freitas and Routledge, 2013; Garris et al., 2002; Gunter et al., 2006; Salen et al., 2004; Zichermann and Cunningham, 2011). With this workshop structure, the worlds of *reality*, *meaning*, and *play* of the participants are defined in a flexible way, which in turn are used to inform the researchers in this study on their preferences, needs and desires (and the resulting requirements).

PROCEDURE

Following the workshop structure, the resulting overall procedure is:

1. Execution of the first workshop
2. Analysis of how well the execution went
3. Revision and improvement of the workshop structure
4. Execution of the second workshop
5. Analysis on how well the second execution went

Information was collected from three types of sources: The first is the feedback provided by the facilitators of both workshops, and written down right after each workshop; the second are the notes and other writings made by facilitators and participants during the workshops at group level; the third is the audio recordings made during the workshops.

This information includes observations from the facilitators on how the workshops went, on the process of the workshops, game ideas, and remarks made. It also includes information on activities that participants normally like to do, locations where they would like to play, and with whom they would consider playing a game.

WORKSHOP 1: PRACTICAL SECONDARY SCHOOL DE HEF

The first workshop is set up to last three and half hours with one break in between, and is composed of the three major parts described above: characterisation of the neighbourhood, brainstorming on game requirements, and the design of a game. Characterisation of the neighbourhood is based on questions presented above to describe their own neighbourhoods in terms of where they are on the map, positioning and describing people and/or organisations, artefacts and activities (phenomena), and drawing relationships between the identified people/objects on a separate piece of paper. Participants are asked to indicate the ideal location for their envisioned gameplay on a map of Rotterdam South.

Brainstorming on game requirements is introduced as a challenge. Participants are primed with several videos that showcase the goals defined above: a game that (1) is fun, (2) is meant to be played in your neighbourhood, (3) with your smartphone, and (4) involving everyone in it. The videos show examples of relatively well-known games (e.g. Pokemon

Go[7], and Google Ingress[8]), but also examples of hardware artefacts that they could use in their game (e.g. interactive projections[9], 3D projection mapping[10], and art installations[11]). After showing the videos, each small group identifies a set of activities that they like to do (or could do) on their own, and a set of activities that they would like (or would like) to do with other people in the identified neighbourhood. As indicated above participants brainstorm on the types of activities that could lead to joint game activities, and by whom (i.e. the major players) The adolescents then define where (major locations), when (the game is to be played), and how (with which devices) the game is to be played, and agree on a name for the game.

The design of the game ideas, the last part, follows the procedure described above. Gamification of this phase for the adolescents in this study entailed inclusion of competition between the groups: the group with the best game idea determined on the basis of voting wins a prize. Groups are advised to have at least one game idea throughout this process, with at most three ideas at any one point. Once each of the groups has agreed on their game idea they are asked to pitch this idea to the other groups; all participants vote for the game idea they like best (other than that of their own group).

Once the winning game is identified, there is an open debriefing session with all participants, which explores why the participants chose the games they did, what they liked the most about those games, and what they liked about the games they did not choose. The feedback is given verbally and audio recorded.

A. Execution of Workshop 1

The first workshop had 16 participants (4 girls, 12 boys) between 12 and 16 years old. After the introduction, these adolescents were divided into 3 smaller groups (5-6 people each). Each group had two facilitators (teachers and researchers) to help with group dynamics.

The participants were interested in creating a game and working together. During the course of the workshop they realised that they would not be creating a game, but that they would be creating a game idea. Despite chocolates, snacks and drinks during breaks, it became clear to the facilitators that the planned duration of 3.5 hours was too long and prolonged participant engagement was an issue. Thus, the workshop was shortened to 2.5 hours total, including the debriefing session.

B. Results of Workshop 1

In total 5 game ideas, a set of activities participants would like to play, with whom, and where, were identified, as described below.

From the data collected (in Workshop structure), a total of 5 game ideas, a set of activities participants would like to play, with whom, and where, were identified, as described below.

[7] https://www.pokemongo.com/en-us/, Pokemon Go, last visited on December 23, 2020.

[8] https://www.ingress.com/, Google Ingress, last visited on December 23, 2020.

[9] https://www.youtube.com/watch?v=t9hniaziHXY, Urban interaction design - Projected Games, last visited on December 23, 2020.

[10] https://www.youtube.com/watch?v=CpRLwLcLHNA, 'Axioma' - 3D projection mapping, last visited on December 23, 2020.

[11] https://www.youtube.com/watch?v=BZNqOSP5w9Y, Best Art installations, last visited on December 23, 2020.

Game Ideas

1. *Keep on Running*: Accomplish challenges given by other players, earn 'gold', the virtual currency of the game, with them, and showcase players' progress with a virtual avatar. The game fosters competition between two groups of players, by allowing each group (and individual members) to create new challenges for the other group to complete (and therefore rendering the winning group some points). Players who create challenges receive a small amount of 'gold', and a bit more when the other team completes their challenge. The game can also produce random tasks for both groups, and the group that accomplishes the challenge first wins the 'gold'. The challenges are of physical nature (in the real world), but also in the virtual game, where the players have to deal with monsters that try to hinder the team in their quest to accomplish the task at hand. One example of a challenge is having players looking for virtual and/or physical objects in the environment, or accomplishing activities in the environment such as running, sprinting, or dancing. When a challenge is performed as a group, all of the elements involved have to provide partial solutions for the challenge for the group to win the 'gold'. Players can also choose a single-player mode, where individual contributions or physical exercises are attributed to their group (e.g. going to the box club, or sports club). Players have a digital avatar that is representative of their condition in the game: the leaner the avatar, the stronger the player's commitment in the game. Items collected through challenges can be used to personalise and enhance the avatar. The game starts when someone enters the game world and forms a group; to do this, a player can send out messages to anyone in the game who is nearby and wants to join the game.

2. *RealCraft Zuiderpark*: This game idea is based on Minecraft™©, in which players can collect assets and build virtual objects. The game has a storyline and allows for players to fight against enemies (e.g. zombies, and the creeper as in Minecraft™©. Players can collect assets from the environment (e.g. wood, stone, or sand), earn points with battles won but also based on their objects built, improve and customise their avatar (new clothes, more colours, more haircuts, etc.), exchange messages (e.g. to trade, collaborate, or build), trade and exchange assets with other players they meet in the game, and build virtual objects in the environment (when together with other players and with a combination of different types of assets). Once such virtual objects are built, other players can see them too, and at first it is meant to be played in Zuiderpark (but could scale up to whole Rotterdam/The Netherlands).

3. *The Voice of South*: The game consists of recording people singing or making music at a specific spot in the neighbourhood, and the game would enable others around to listen to it on the spot and rate player's performances. The best songs/raps/clips would be on top of the leader boards resulting in increased social status and visibility.

4. *Water Ball*: This game idea consists of having people throw virtual balls at each other with their smartphone. Instead of losing when being hit, a player receives points from the thrower/attacker, and he or she only receives points when different people throw balls at him/her. The purpose of the game is to increase contact on the street, as a

means to meet new people. This game of throwing balls is considered to be a way of interacting.

5. *Eat & Go*: This game consists of collecting points by walking around Zuiderpark, a park in the south of Rotterdam, or challenging other people in sports competitions. The points collected by the players (either individually or as a group) can be used to acquire food from supporting companies for free, and the more points collected, the more variety of food the player can get. This game can be adapted to things other than food, and can also consider joint activities among the players (e.g. Flash Mobs, voluntary work like garbage collection or helping others repairing things). Players randomly encounter challenges while walking around Zuiderpark, and these challenges make players win or lose points.

Which Activities? Participants like to slide, to climb, run, free running, basketball, dance or break dance, do sports, cannoning, swim, make music, eat with others, barbecuing, get to know people, visit each other, doing things together, send messages, sit under the sun, chill outside in the evenings, challenge each other, throw water balloons, fight, play Hide and Seek, Call of Duty, Counter Strike, Mario Kart;

With whom? Participants like to play with parents, friends, boys, girls, 10-20 year aged, sick people, antisocial adolescents, people that do activities, everybody; the police, war refugees;

Where? Participants would like to play in parks, a residential area, outside, bakery, square, market, swimming pool, stores, cinema, on the grass, supermarket, football club, everywhere in the neighbourhood, hangout place.

C. Analysis of Workshop 1

The first workshop worked well in general, with 3 groups with 2 facilitators each . The adolescents were willing to talk about their homes, where they lived, but also about criminality and boredom. In some cases facilitator intervention was needed to prompt participant contribution. The examples of real games and game elements presented in the brainstorming part of the workshop seemed to work well, as did the competitive nature of the challenge to design the best game idea (as reported by the facilitators and participants). The structure and duration of the workshop, however, were problematic as indicated above.

The levels of productivity, interest in participation, collaborative attitude, and disruptive behaviour varied across groups (despite the voluntary nature of their participation). Adolescents also varied in their knowledge of the area (i.e. was often very limited; some were not allowed to play on the streets by their parents), and their map reading skills were limited. The main challenge was, however, that the participants thought they would be creating a real game and not "just" a game idea.

The toolkit used to support game design was perceived by most to be more complex than necessary, and the rules of the competition between groups (i.e. the gamification of the workshop, the pitch of the ideas, attribution of the points, a winner and rewards) were not clear to all participants from the start).

The debriefing session was not as productive as envisioned: a few participants contributed to the discussion indicating which game they liked best (and for which they had voted) and which activities they liked best. All others agreed with what had been said, adding very little to the discussion.

Workshop 2: Secondary School STC

The workshop structure was revised on the basis of the experience described above. The title of the workshop was changed from "Ontwerp een Game" (Design a Game), to "Bedenk een Game" (Devise a Game) to manage participant expectations: to indicate that the workshop is to explore and devise ideas for games, but not to create them.

The second change related to the structure of the workshop and its duration. The workshop is based on TGD's worlds of *reality*, *meaning*, and *play*, and all three are of importance. Insights on the world of reality, namely characterisation of the neighbourhood, were acquired during the first part of Workshop 1.

The structure of Workshop 2 was therefore slightly different: the first part of the workshop on neighbourhood characterisation was replaced by a short physical game.

A. Execution of Workshop 2

The second workshop had 15 participants (12 boys, 3 girls) between 12-16 years of age. It started with an introduction of the purpose of the workshop, followed by the actual play of a game outside (Moon Ball (Sweeney and Meadows, 2010)). Thereafter, participants moved inside and were introduced to the challenge of the workshop and its competitive nature, were primed in the same way as the 1st workshop, and were further divided into groups of 5. One of the groups had only one facilitator (a researcher), and the other two groups had two facilitators per group (one researcher, and one teacher from the school) to help with group dynamics.

B. Results of Workshop 2

In total 4 game ideas, a set of activities participants would like to play, with whom, and where, were identified.

Game Ideas

1. *Minecraft*™© *Go*: The game idea is to play Minecraft™© in the real world, i.e. to place Minecraft™© content in the neighbourhood and to create places to play and meet each other. Players can perceive and become part of the fantasy of others, and see whether their own buildings withstand natural disasters (e.g. flood, earthquake, or volcanoes). Players can choose a specific style of building, have a personal logo, an avatar with its own style, and compete with other players for the largest number of buildings built with the different types of resources. Players can advance throughout the game by making friends with other players, trading construction objects and building with them, and going through the storyline and assignments of the game (e.g. build a structure with 100 other players). The game enables ownership of a region, i.e. for players to build walls, create their villages, and invite friends to build in their villages. Players need to move around the neighbourhood to collect unique resources, and to trade those with others.

2. *GTA Rotterdam*: As in the "normal" GTA™©, a player receives assignments to follow someone, to find something or someone, to kidnap someone, or to discover hidden

drugs. In the course of the game, players are equipped with a water-gun and a virtual dog to help in chasing suspects. The faster a player is in his or her assignments, the better he/she scores. The less water he/she uses from his or her water gun, the more points the player earns. Players can negotiate with other players about assignments or support for each other. They can message each other with their mobile phone. As each player can also be chased by others, there are also safe places in the environment. The winner is the player who earns the highest number of points.

3. *Habiba Challenge*: Habiba is a challenge game, related to sports and other activities. Players can assign challenges to each other, and they can collaborate and teach each other new skills, like tricks on a bike. They can also develop challenges, like eating the most chicken, or hitting each other with a soft ball. Points are gained by winning a challenge; the player with the highest score wins.

4. *The Walking Egg*: This game is similar to Pokemon Go™©, as it consists of actions related to objects in the real surroundings. Each player has a map at his or her disposal showing a map with the real surroundings, the main mission (throwing digital eggs at each other to gain points) and side missions. Bonus points can be collected via the side missions and collectable items (e.g. Chicken Drops that drop extra eggs, quick egg-throwing weapons, or golden eggs that multiply the points earned), but also by walking around in real life. The players have to throw eggs to acquire points to build their farm. Every player has a farm which h/she has to manage, and new elements can be added to the farm (with either points or items collected in the virtual game). Points can be used to buy upgrades for the farm, and real money can be used to acquire such points as well.

Which Activities? Participants like to play football, dance, free running, cycle, throw eggs, make music, look for trouble, irritate people, hang out, build ships and sail them, listening to music, eat, chill, see who can eat the most chicken, play treasure hunt, playing catch, hit ball, hide and seek, play Monopoly, card games, shooting games, Minecraft™©, Pokemon GO™©, FIFA™© 17, Assassin's Creed™©, Candy Crush™©, Call of Duty™©, Ship Simulator;

With whom? Participants like to play with friends, boys/girls from the neighbourhood, people doing groceries, people with dogs, delivery people, young people, mediocre people, old people, black, white, and Asian, everyone except creepy people, police agents, soldiers, problematic youth, with everyone, including people that participants do not know yet, as long as they are close to the participants' same age;

Where? Participant like to play in parks, school square, shopping streets, shops, bus stops, water park, skate lanes, around in the neighbourhood, anywhere in the neighbourhood, any time (preferably during evening), spare time (i.e. afternoons, weekends, and at night);

C. Analysis of Workshop 2

The second workshop was reported by the facilitators to be more effective than the first workshop. They reported that in two of the three groups much less support was required from the facilitators. Most adolescents enjoyed thinking of elements for the game, and were less disruptive. The shorter set-up and focus on the play aspect resulted in more engagement with the card toolkit. Some of the cards in the card deck were still too difficult, although some of the adolescents really read the cards and tried to implement the elements in the game. The "world of meaning" was done in less than half an hour, while the world of play and the process of creating the drawings for the game took longer than the allotted 40 minutes.

Even though gaming is a mutual part of the participants' culture, and the participants understand the elements of a game the task of thinking about games does require some attention and conceptual thinking skills. In one particular group (the one that produced the game ideas: GTA Rotterdam, and Habiba), the facilitator noticed early on that part of this group had a clear preference for shooter games with some level of violence. The choice of facilitation was to allow for unrestrained flow of thoughts (which then resulted in the GTA Rotterdam). The group dynamics were challenging: the facilitator reported that not all participants were in favour of violence but that two of the older boys constantly tried to dominate the discussion and to intimidate the facilitator and other participants through aggressive behaviour and jokes. The game Habiba was the result of the facilitator's intervention to guide the design process to support a game idea without violence on purpose, in particular for the younger participants of that group whom seemed to be open to collaborative games, and activities that can be shared and are challenging.

The debriefing session was slightly more effective than in Workshop 1. One facilitator indicated that this workshop was more effective than the first and that one of the games was much more detailed and therefore better (while referring to The Walking Egg) than the games devised during the first workshop. One of the groups debated "older" people's willingness to engage in a game, and the feasibility of going outside and doing "something with strangers in their neighbourhood" although appealing.

4.1.2. Data analysis

Games often purposefully evoke different emotions in players by deploying a certain number of game dynamics. Understanding the emotions and the related game dynamics of a game is therefore an important step in the analysis of game requirements for a certain purpose, such as social interaction. The MDA framework (Hunicke et al., 2004) distinguishes 9 possible aesthetics defined as "desirable emotional responses evoked in the player": sensation, fantasy, narrative, challenge, fellowship, discovery, expression, submission, and competition. Hunicke et al. (Hunicke et al., 2004) define game dynamics as: "the run-time behaviour of the mechanics acting on player inputs and each other's outputs over time". Building upon these aesthetics, this article employs the MDA framework for the requirements analysis. Though several other frameworks exist (Mora et al., 2015; O'Shea and Freeman, 2019) (e.g. Elemental Tetrad (Schell, 2008), MTDA+N (Ralph and Monu, 2014), DPE (Mellecker et al., 2013), DDE (Walk et al., 2017), and gamification-related (Chou, 2015; Jiménez and Escribano, 2017; Kumar, 2013; Morschheuser et al., 2017; Werbach and Hunter, 2012)), the MDA framework, in comparison, enables game developers and practitioners to decompose, study, and design game designs and artefacts in a structured way, and provides one fundamental approach to game design: it decomposes every game into a set of rules that lead to a system of play, and that, in turn, generate a "fun"-based play experience (Hunicke et al., 2004). MDA establishes a counterpart relationship (from the rules → system → play experience) that provides a functionality-oriented perspective (mechanics → dynamics → aesthetics) that has shown to be useful to analyse games (Duarte, 2015). MDA offers a "workable" mental model for how information is created and received in a game, and simplifies the chain of events by creating a hierarchy of game components and basic elements (where mechanics are at the foundation of a game) (Polansky, 2015). This model makes it possible to analyse existing game ideas and designs in their underlying functionality, to identify requirements on which they are based.

In summary, this research uses the MDA framework due to 1) its wide acceptance by the scientific community (Walk et al., 2017), 2) its practical functionality-oriented approach, 3) its grounding in emotions (aesthetics) and involvement of players, and 4) its value for analysis of game ideas and identification of requirements reported in this case study (see appendix A).

The novel requirements analysis process described in this section focuses on understanding the aesthetics of the 9 game ideas and the game dynamics proposed. All game ideas are analysed firstly at the level of the aesthetics (emotions) they elicit, and secondly at the level of dynamics used for their implementation. Other results produced during the workshops (those regarding "which activities", "with whom", and "where") were informative but not with respect to the aesthetics and dynamics involved. Detailed analysis on the game ideas can be found in appendix A.

Protocol of analysis

Each of the game ideas developed by the adolescents was analysed by 2 researchers to identify the aesthetics invoked and the game dynamics responsible for their invocation. The set of possible game dynamics used during the analysis is based on different sources: a library of game mechanics (Järvinen, 2009), game mechanics from the AddingPlay card deck toolkit (Sisarica, 2015), and the SCVNGR's secret game mechanics/dynamics play deck[12]. In the first stage of analysis, two researchers independently analysed and classified the aesthetics they identified in the game ideas given by the participants. In the second stage of analysis, they used this set of possible game dynamics to code, per game idea, the way that the identified aesthetics are technically supported. The resulting lists of aesthetics and game dynamics were cross-validated, adapted when necessary through agreement on what dynamics best describe the entailed gameplay aesthetics/experience. The supplement material to this case study (appendix A) provides a detailed account on the identified list of dynamics, and where and how often each of them occurs.

Game dynamics for location-based games fostering social interaction

Table 4.1 shows the several game dynamics that were identified in the game ideas from the two workshops. This list presents the name of the dynamic on the left column, and, on the right one, the descriptions derived from the game ideas.

Dynamic	Description
Achievement	Provide a sense of accomplishment to the player, either as an individual or as a group, resultant from task completion.

[12] https://techcrunch.com/2010/08/25/scvngr-game-mechanics/, SCVNGR's Secret Game Mechanics Playdeck, last visited on December 23, 2020.

Table 4.1 (continued)

Collaboration	Enable players to achieve a shared goal by working together, that may be necessary to advance the game play.
Collection	Promote player's return to the game by creating an objective of collecting items in the game that can be accomplished over time and several gameplay sessions. Collection is the act of gathering game elements in the game environment (either digital or real world) for the purpose of ownership, trade, or improvement of condition.
Community Contribution	Impact the real environment, outside of the game, by involving other people whom are not actively playing the game, or by creating positive influence of gameplay for the neighbourhood.
Digital Interaction	Promote play and engagement by influencing communication between players, whilst also allowing them to influence the gameplay of other players in the digital world. Digital interaction happens for example in the form of communication, digital group formation, or multiplayer mode.
Exertion	Motivate players to do activities involving physical effort, to advance in the game. This involves physical effort that is required to perform an activity or solve a challenge linked to the game.
Lottery	Add surprise to the game and prevent the player from getting used to the game with random events that affect the gameplay or its outcome.
Mission	Add fantasy and overall purpose to the gameplay, through a tale, general narrative, or as overall mission or smaller missions that add to the overall tale.
Ownership	Enable players to participate, own and be responsible for part of the game content, to (partially) own the game and influence other players' gameplay.
Reinforcement	Foster play and engagement, e.g. provide a reward when a certain action or outcome occurs.
Real-world Play	Embed the play in the physical environment and allow players to be physically active.
Social Interaction	Establish interaction and face-to-face communication, either with other players or with other people not actively playing the game.
Virtual Representation	Increase the player's presence in the game by digitally representing the player's state, visibility, or social status.
Winning Condition	Quantify success and accomplishment within the game. A winning condition either implies a comparison and competition between players, or a competition between the player and the game. These are required conditions to complete game tasks.

Table 4.1: Game dynamics resulting from the game idea analysis.

Table 4.2 shows the number of times the game dynamics identified in table 4.1 were found for each aesthetic and each game, in a descending order. In theory, with 9 game ideas and 9 aesthetics, a given game dynamic could be counted up to 81 times (9 game ideas x 9 aesthetics per game idea).

Dynamics	Frequency	Literature
Achievement	45	(Consolvo et al., 2006; Hinske et al., 2008; D. Parsons et al., 2006; J. Yim and Graham, 2007)
Real-world play	27	(Eriksson, 2005; Hinske et al., 2008; Nilsen, 2006; Straker et al., 2014; Valente et al., 2017; Wetzel et al., 2008; Zagal et al., 2000)
Reinforcement	25	(Chilufya, 2014; Consolvo et al., 2006; Gennari et al., 2019; Mascio et al., 2013; D. Parsons et al., 2006; J. Yim and Graham, 2007)
Social Interaction	24	(Chilufya, 2014; Eriksson, 2005; Ermi and Mäyrä, 2005; Hinske et al., 2008; Isbister and Mueller, 2015; Korhonen and Koivisto, 2007; Straker et al., 2014; Valente et al., 2017; Wetzel et al., 2008; J. Yim and Graham, 2007; Zagal et al., 2000)
Collaboration	18	(Chilufya, 2014; Eriksson, 2005; Ermi and Mäyrä, 2005; Hinske et al., 2008; Korhonen and Koivisto, 2007; Nilsen, 2006; D. Parsons et al., 2006; Valente et al., 2017; Wetzel et al., 2008; Zagal et al., 2000)
Digital Interaction	17	(Choi and Kim, 2004; Consolvo et al., 2006; Eriksson, 2005; Ermi and Mäyrä, 2005; Korhonen and Koivisto, 2007; Korhonen et al., 2008; D. Parsons et al., 2006; Valente et al., 2017; Wetzel et al., 2008; J. Yim and Graham, 2007; Zagal et al., 2000)
Ownership	17	(Consolvo et al., 2006; D. Parsons et al., 2006)
Winning Condition	12	(Consolvo et al., 2006; Ermi and Mäyrä, 2005; D. Parsons et al., 2006; Zagal et al., 2000)
Collection	10	(Al Mahmud et al., 2010; Ermi and Mäyrä, 2005; Hinske et al., 2008; Nilsen, 2006; Valente et al., 2017; Wetzel et al., 2008; J. Yim and Graham, 2007)
Exertion	10	(Consolvo et al., 2006; Eriksson, 2005; Ermi and Mäyrä, 2005; K. Gerling et al., 2012; Hinske et al., 2008; Korhonen and Koivisto, 2007; D. Parsons et al., 2006; Straker et al., 2014; Valente et al., 2017; Wetzel et al., 2008; Zagal et al., 2000)
Virtual Representation	10	(Ermi and Mäyrä, 2005; Isbister and Mueller, 2015; Mascio et al., 2013; D. Parsons et al., 2006; Straker et al., 2014; Wetzel et al., 2008)
Mission	8	(Chilufya, 2014; Ermi and Mäyrä, 2005; Hinske et al., 2008; Mascio et al., 2013; D. Parsons et al., 2006; J. Yim and Graham, 2007)

4

Table 4.2 (continued)

Community Contribution	6	(Chilufya, 2014; Eriksson, 2005; Ermi and Mäyrä, 2005; Korhonen and Koivisto, 2007; Korhonen et al., 2008; Nilsen, 2006; D. Parsons et al., 2006; Straker et al., 2014; Valente et al., 2017; Wetzel et al., 2008; Zagal et al., 2000)
Lottery	3	(Al Mahmud et al., 2010)

Table 4.2: Frequency (**Frequency**) of the game dynamics (**Dynamics**) in the game ideas (refer to the supplementary materials for a full analysis). Also shows references to the literature (**Literature**), i.e. how each requirement compares to other guidelines.

Table 4.2 shows that *achievement* occurs most frequently, 45/81 times. *Real-world play* (27/81), *reinforcement* (25/81), *social interaction* (24/81), and *collaboration* (18/81) are the dynamics that are then most frequently deployed. *Digital interaction*, *ownership*, and *winning condition* (17/81) scored equally. On the lower spectrum, *collection* (12/81), *exertion* (10/81), *virtual representation* (10/81), *mission* (8/81), *community contribution* (6/81), and *lottery* (3/81) are the dynamics least used by the participants.

This sorted list of game dynamics reflects what the participants in this target group prefer and desire with regard to gameplay and functionality of future location-based games designed for social interaction. This list, in fact, represents these participants' high-level requirements.

4.1.3. Discussion and Limitations

This sub-chapter discusses the results of this research, as well as how they compare to existent non-user-centred guidelines and requirements found in the literature (the rightmost column in table 4.2). A new aesthetic is proposed in this discussion, and limitations discussed.

Discussion of results

From the sorted list of game dynamics found in table 4.2 the game dynamic *achievement* stands out most (it is present in 56% of the aesthetics in the game ideas). This means that a sense of accomplishment is of importance to this target group. At a lower level but still prominent are the dynamics *real-world play*, *reinforcement*, and *social interaction*, mentioned for just over 30% of the aesthetics in the game ideas. This means that after the sense of accomplishment, the participants prefer gameplay with physical movement embedded in the real world, with rewards, and with interaction with people. In addition *collaboration* (22%), *digital interaction*, *ownership* (21%), and *winning condition* (15%), and to a lesser extent, the dynamics *collection* (12%), *exertion* (12%), *virtual representation* (12%), *mission* (9.8%), *community contribution* (7.4%), and *lottery* (3.7%) appear to interest adolescents as well. Future designers of a location-based game for social interaction can take heed of these preferences, i.e. requirements of this target group in future design.

Comparison between results and existent guidelines

Research on social interaction recommends that players have "multiple channels for communication" at their disposal (Eriksson, 2005). This is in line with the Ermi et al.'s guidelines

(Ermi and Mäyrä, 2005), to "allow different modes of play and support various player types", to "allow as much free communication between players as possible" and "support the forming of teams and alliances". Korhonen et al.'s (Korhonen and Koivisto, 2007; Korhonen et al., 2008) guidelines include playability heuristics for online player-to-player interaction with mobile phones, and off-line communication with others. Zagal et al.'s (Zagal et al., 2000) guidelines distinguish natural (out-of-the-game) and stimulated (in-game) interaction, how collaboration and competition occur in both, and how games should allow for meta-gaming (with physical interaction).

The guidelines proposed by the above-mentioned authors link to the requirements this case-study proposes for digital and social interaction (*collaboration*, *exertion*, *real-world play*, and *community contribution*) and to those related to different modes of play to support different types of gaming activities based on *collaboration*, *winning conditions*, *collection*, *exertion*, and small/large *missions*.

Other guidelines stress digital interaction more, or in-door interaction. Design of social interaction in the digital world only is supported by guidelines proposed by (Choi and Kim, 2004; Isbister and Mueller, 2015; Straker et al., 2014) for *virtual representation*, anonymity, and self-expression. Research on indoor social interaction focuses on in-class behavioural education (Gennari et al., 2019), and stresses that points and progression bars on interactive solutions help the development of children (which links to our requirement on *reinforcement*).

Research on physical mobility focuses on the different possibilities that real-world play affords, whether it be for *exertion* or for interaction afforded specifically by tangible objects described below. Research on AR games proposes games that do not stay digital (links to *collection*), use the real environment (links to *real-world play*, *exertion*, *social interaction*, and *community contribution*), and that use various social elements (links to *virtual representation*, *social and digital interaction*, *community contribution*, and *collaboration*) (Wetzel et al., 2008). Regarding *exertion*, work encouraging physical activity is vast (Chilufya, 2014; Consolvo et al., 2006; K. Gerling et al., 2012) and recommends support for social influence (social pressure, support, and communication), fun, along with awareness of the activity level, and recognition of users. Straker et al. (Straker et al., 2014) propose recommendations for players to "be social", "swap sedentary with active games", and to promote games with "positive social content" that lead to "fun". These recommendations link to our requirements on *real-world play*, *exertion*, *community contribution*, *achievement*, *reinforcement*, *winning condition*, *social/digital interaction*, and indirectly to the recognition that users acquire by contributing to game design (*ownership*). Our requirements of *reinforcement*, *achievement*, *collection*, *mission*, and *social/digital interaction* are further linked to the sense of progression, achievable short-term goals, and the assistance of team formation that are found in (J. Yim and Graham, 2007).

Regarding tangible objects, Mahmud et al.'s work on inter generational indoor games (Al Mahmud et al., 2010) provides insights on social interaction that are linked to the use of *lottery* and tangible objects, as ways to add appreciated uncertainty in the game. The quality requirements proposed by (Valente et al., 2017) with respect to AR-based games include "social communication", "involving non-players", "game object tangibility", and "local-space redefinition". Guidelines stress not only the importance of novel interactions afforded by tangible objects, but also of the interface (and how to balance all of the elements of the game) (Nilsen, 2006), and the inclusion of players of different ages (Chilufya, 2014). Other guidelines (Al Mahmud et al., 2010; Chilufya, 2014; Hinske et al., 2008; Nilsen, 2006; Valente et al., 2017) discuss object tangibility and the interpersonal interactions these support, and link directly to a few of the requirements proposed in this article (*digital and social interaction*, *exertion*, *community contribution*, *real-world play*, *collection*, *collaboration*, and *collaboration*), all the while having implications (or be used) by others (*lottery*, *mission*, and *achievement*).

Lastly, social interaction is included in guidelines for games with very different goals such as learning environments (Gennari et al., 2019; D. Parsons et al., 2006), for children with special needs such as deaf children (Mascio et al., 2013), but also for blogs, wikis, and discussion groups (D. Parsons et al., 2006). Such guidelines link to our requirements of *reinforcement*, *mission*, *virtual representation*, *ownership*, *community contribution*, *exertion*, *collaboration*, *winning condition*, *achievement*, and *digital interaction*, with one exception. Mascio et al.'s work reports that deaf children do not enjoy interaction with others and that they often suffer from excessive distractions by other people (i.e. multiple communication channel reported above) (Mascio et al., 2013). Often their (single player) gameplay, however, does require support from other people (parents or teachers), with progressive challenges, explicit in-game rewards, and collaborative customisable avatars, that resonate with many of the requirements this case-study proposes (*mission*, *reinforcement*, and *virtual representation*) and the support they give to players.

This comparison shows that the requirements proposed in this article that stem from adolescents, are linked with existing work in different ways. These results, however, can be misleading. Although there is overlap, there are also differences: not all guidelines are aligned. The lack of consensus is primarily due to differences in the types of games and purposes on which they focus, and none of the research discussed focused specifically on location-based games for social interaction.

Two of the requirements proposed in this case study (*ownership* and *lottery*) are not strongly linked to existing guidelines, and are thus novel to the adolescents in the studied neighbourhoods of Rotterdam.

SUITABILITY OF THE MDA FRAMEWORK

The aesthetics identified by the MDA framework, and the game dynamics to which they were related provided a strong basis for requirement analysis. One game idea, however, was not covered by the 9 aesthetics the framework distinguishes. The game description of Eat and Go mentions the adaptation of the game to aspects other than food, to joint deeds such as voluntary work or providing help in repairing assets for others, or engaging in activities such as cooking or eating (without winning conditions). For this case in particular, this case-study proposes to extend Hunicke et al's list of aesthetics (Hunicke et al., 2004) to include Care, an aesthetic for players looking for a gameplay aimed at contributing to the community. Games with this aesthetic invite players to engage in offline community building, care for the community, the environment, and the people in it.

The list of game dynamics identified in this research is not extensive, complete, or closed, and results from the two described workshops. New game ideas can potentially extend and advance these definitions of dynamics. Nonetheless, the list of game dynamics is well founded, and can guide future game design for social interaction.

ATHLETE AND INVENTOR: TWO TYPES OF GAMING ACTIVITIES DESIRED BY USERS

The activities that participants informed wanting to do, with whom, and where, shed light on the type of content that they want to play in a game for their neighbourhood. Many activities have a physical nature (or even of exertion, e.g. to climb, to run), and these make a substantial part of what they mentioned liking. Another type of activities they reported enjoying involve creativity (e.g. make music, treasure hunt, build ships and sail them). This can be linked to the neighbourhood and how to enable adolescents to think about ways to improve their own world and make it more liveable (Fonseca et al., 2017). Therefore, this case study proposes two types of activities that users seem to want to play in a game fostering social interaction in their neighbourhood[13]:

> **Athlete**: Athlete type of challenge requires physical activity to solve the challenge. The challenge can be solved by either doing a specific activity requiring physical action (e.g. engaging with at least five people for a given purpose), or by varying the quality of the performance itself (e.g. see who can finish the free-running the fastest).
>
> **Inventor**: Inventor type of challenge require players to propose new ideas to address an issue in the neighbourhood. Players in this type of challenge may explore interventions for their neighbourhood, and explore opportunities to increase the livability of their neighbourhood. Examples of this challenge are possible interventions to change their neighbourhood, designing a new playground, or a new colour scheme for the location.

4

LIMITATIONS

A major limitation of this study is the small data set gathered from the participants. More game ideas, from a varied pool of participants, can in future address this limitation and provide support for more significant claims. The results reported in this case-study are, however, of scientific value, especially due to the exploratory nature of the study in complex and realistic settings to understand adolescents' preferences for interaction with the neighbourhood in which they live, and the people it includes.

Participation in the study was voluntary, and the selection procedure open. The assumption was that adolescents who volunteer to participate in workshops for the design of a game are motivated and interested in this challenge. As indicated above adolescents' expectations for the first workshop were not aligned with the goals of the workshop, and was thus adapted for the second workshop: a limitation in itself.

In addition with respect to gender, the sample of participants in total is not gender-balanced (of the 31 participants, 24 were boys and 7 were girls). This fact may skew the findings towards more male-oriented values and styles of gameplay, which, when coupled with the gamified workshops (designed towards mild competition. The sample of participants was, however, judged by the schools to be representative of both the students in these schools and of the neighbourhoods involved. Future work can explore the effects of this possible bias on requirements for LBGs for social interaction.

[13]This lesson learned is also included in the published article: G. Slingerland, X. Fonseca, S. Lukosch, and F. Brazier, *Location-based Challenges for Playful Neighbourhood Exploration*, Behaviour and Information Technology, doi: https://doi.org/10.1080/0144929X.2020.1829707, 2020.

An aspect not covered in this case study is the priming effect of participants' prior knowledge of non-location-based games. Game ideas such as RealCraft ZuiderPark, Minecraft Go, GTA Rotterdam, and The Walking Egg are similar to location-based counterparts of known commercial games such as GTA, Minecraft, and Pokemon Go. Future work should take previous gaming experience of participants into account.

Summary

This case study seeks to understand the preferences, needs and desires of adolescents living in two neighbourhoods in the south of Rotterdam, The Netherlands. It explores which requirements adolescents have to play outdoor digital games for social interaction in their neighbourhood, and understand their context. Different social contexts, even inside the same country, can potentially reveal details that are not apparent to game designers, highlighting not only the importance of involving future players in the process of requirements elicitation, but also the potential for games to explore novel ways to expose adolescents to their surroundings and the people in them.

A list of game dynamics as high-level requirements for location-based games fostering social interaction is proposed, based on in-depth analysis of aesthetics and dynamics using the MDA framework (Hunicke et al., 2004). This article proposes to extend the MDA framework with a new aesthetic called "***Care***", given that the original set of aesthetics does not cover certain details that are important to the participants. This aesthetic covers games aimed at contributing to the community, by caring for the neighbourhood in general, and promoting engagement meant to nurture and maintain it. The game dynamic *achievement* is predominant (in over 50% of the aesthetics and game ideas) indicating the adolescents' strong need to have a sense of accomplishment, resultant from completing tasks either by themselves or with others. This research argues that all identified game dynamics are important, and indicates to a varying degree what participants of this age would like to experience in future games fostering social interaction.

For future work it is important to understand how different participants in different locations can contribute to the proposed list of game dynamics for location-based games fostering social interaction (even from the same target group used). The identified game dynamics are at a high level and need to be further specified, e.g. proposing possible design patterns describing how to put game mechanics and elements together to provide these dynamics of play. As human emotions are numerous and complex, further research is recommended on the topic: having a more complete taxonomy of aesthetics can help structure the process of game design and make it less dependent on individual game designer's preferences. In addition, the relationship between the list of game dynamics identified in this case study and the degree to which social interaction is fostered, should be further explored. That will shed light on the relative importance of each requirement with respect to (the type of) social interaction involved.

4.2. CASE STUDY 2: USER REQUIREMENTS FROM ADULTS IN THE HAGUE

All grown-ups were once children... but only few of them remember it.

Antoine de Saint-Exupéry

The second case study aims at exploring gaming activities that are designed according to the literature on social cohesion and interaction (thus non-user-centred), and assess their efficacy in triggering social interaction in environments that are not-known to users. It explores the design of gaming activities, named challenges, to probe users in different ways of interacting, and understand their requirements from the perspective of adults. It uses 5 types of challenges guided by literature to probe how users react to the prepared gameplay. These challenges are supported by an LBG prototype that is developed as a game framework to run them. This LBG is a prototype built on top of the information reported in case study 1 (gameplay requirements from adolescents). This case study tests this LBG plus challenges in its ability to provide a gameplay experience with different players (adults) that do not know each other, and in a location not-known to them.

By doing so, this case study explores user requirements from the perspective of adults and adds to the perspective of adolescents, for it is assessed in which way the prepared gameplay (i.e. the 5 types of challenges) meet the users' preferences, needs, and desires. Following sections briefly describe the game framework used, focus on the experiment, report on 5 different types of challenges played by strangers in an environment not-known to them, and discuss the lessons learned on the appropriateness of the challenge designs offered to players.

4.2.1. GAME PROTOTYPE

The created game prototype is a location-based game that lets players walk around their neighbourhood and other public spaces, engage with people they (might) have never seen or spoken to before, go to places that they might have never been or seen before, and solve challenges together with other people (actively playing the game or not) to advance throughout the game. It is designed to support people playing together, hunting for QR codes that other people have, perform in multiplayer challenges, and solving single player quiz challenges designed for face-to-face interaction in the neighbourhood.

Challenges within the game framework are purposefully placed in specific places in the environment. These places can be related for e.g. to the history of a city (e.g. the birth of a legend, the biggest port in the world, a local star) or to local activities. This prototype supports two different types of challenges, quiz and multiplayer: quizzes are designed for

This chapter is based on the published article: X. Fonseca, S. Lukosch, and F. Brazier, *Fostering Social Interaction in Playful Cities*, in Interactivity, Game Creation, Design, Learning, and Innovation, vol. 265, Part of the Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering book series: pp. 286-295, Springer, 2019.

single player gameplay, and multiplayer challenges for groups of people playing together in teams (teams against teams). This study explores multiplayer challenges in which teams solve a challenge, get points/rewards for the quality of their performance, and compete with other teams.

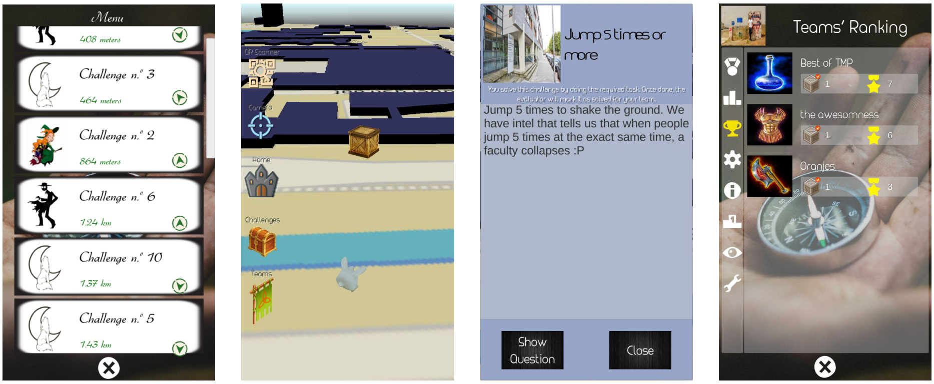


Figure 4.3: LBG prototype used.

4.2.2. CHALLENGE DESIGNS

To foster social interaction in public space, this case study explores the impact of 5 different challenges for scenarios in which people (most likely) do not know each other beforehand (common fact in public space). It explores the goal of fostering social interaction, and uses several factors from the social cohesion framework (Fonseca et al., 2018b) to design these challenges. This framework distinguishes 3 factors that influence social cohesion with regard to an individual (in contrast to communities and formal institutions): (1) self-motivation, (2) perceptions, norms and values, and (3) participation and performance. Social interaction, a means to acquire social cohesion (Festinger et al., 1950; Groenewegen et al., 2006; N. Polansky et al., 1950), is influenced by aspects such as for e.g. intimate face-to-face communication (Cooley, 1909), quality of intimate topics shared (J. P. Stokes, 1983), degree of like-dislike (A. J. Lott and Lott, 1966), sense of belonging (CoE, 2008), individual participation (Braaten, 1991), and task competence (Festinger et al., 1950). Table 4.3 lists both the factors linked to social interaction in this framework, and aspects of influence.

This research uses these factors to create game challenges that are not user-centred, but that can guide what is offered to users in a purposeful way. The following challenges are designed to explore the influence of these factors in practice and promote social interaction, and are explained below (the description of the challenges actually presented to participants can be found in appendix B:

- **Challenge 1: Guess if you can**. The objective of this challenge is to introduce players of a team with each other to jointly solve in a collective problem solving task. It consists of estimating the precise volume of a big and complex building at a given

Factors fostering social interaction	Aspect influencing the factors
Self-motivation	1. Intimate face-to-face communication (Cooley, 1909) 2. Quality of intimate topics shared (J. P. Stokes, 1983)
Perceptions, norms and values	3. Degree of like-dislike (A. J. Lott and Lott, 1966) 4. Sense of belonging (CoE, 2008)
Participation and performance	5. Individual participation (Braaten, 1991) 6. Task competence (Festinger et al., 1950)

Table 4.3: Main goals for challenge designs, and aspects that can achieve them.

location, while stipulating a time limit of 5 minutes. This exercise is designed to require the least effort and act as ice breaker. It addresses the aspects in table 4.3 by initiating communication and collaboration in the same location (aspects 4, 5) without need for intimacy, and making people solve a common problem with time pressure (aspect 6).

- **Challenge 2: Shape in**. The objective of this challenge is to interact in a fun and different way, and to tap into each other's creativity. It consists of having all team members putting on blindfolds and forming a large circle with a rope on the floor. Together they must create a geometric shape with the rope by communicating. It addresses the aspects in table 4.3 by requiring imagination (aspect 6), using blindfolds (aspects 1, 4, 5), and implementing intercommunication to coordinate the task (aspects 1, 3, 4) in close body proximity (aspect 1, 2, 4).

- **Challenge 3: Creative dance**. This challenge is designed to stretch comfort zones, and foster the thrill of creative effort in an engaging and fun way. The team can earn rewards by uniting as a group and making a performance of the three musketeers fighting for a princess (they choose the princess). This entails placing a speaker on the floor, playing music of choice, and team performance. It addresses table 4.3 by creating memorable experiences via a joint dance (aspects 1, 3, 5, 6), and stretching comfort zones in close body proximity (aspects 1, 2, 3).

- **Challenge 4: Creative talk**. This challenge is designed to overcome communication barriers through creativity, to build on each other's knowledge and consider other perspectives. This is done by making the team coordinate without speaking out loud. A unique secret number is whispered to each person, and the team has to line itself up in a numerical order without talking. Difficulty can be added by using numbers from 11 to 99. It addresses the aspects in table 4.3 by deploying blindfolds (aspects 1, 4, 5), requiring creativity in new ways of communication (aspects 5, 6), inviting communication through gestures and close proximity (aspects 1, 2), and inviting touching between players (aspects 3, 4).

- **Challenge 5: Knot**. This challenge seeks to enable team members to provide support to each other to solve a problem. It requires players to create a knot with their own hands, and untangle themselves. To do so, they are asked to form a circle, stretch their right arm forward and grab a random hand. They then do the same with their left arms.

It addresses table 4.3 by deploying touching (aspects 1, 2, 4), mutual support (aspect 4), and close body proximity (aspects 1, 2, 3, 4).

Below, the suitability of these challenges for playful social interaction are explored, within the mentioned existent game framework, and targeting strangers within an urban outdoor environment. The order of the challenges is relevant, because there are challenges that require levels of intimacy (due to blindfolds, touching, and dancing acts) to be played, and build on top of previous interactions. The following section explores whether these challenges foster interaction between strangers (attending a scientific meeting), in an environment they do not know à priori, through reported levels of 1) self-motivation, 2) perceptions, norms and values, and 3) participation and performance.

4.2.3. RESEARCH DESIGN

An experiment was conducted to assess the validity of the proposed challenges introduced in the prototyped game framework. It was executed within the context of the TMP graduate consortium[14] in The Hague, an annual meeting for doctoral candidates, their direct supervisors, and faculty member representatives from around the world. This meeting provided an opportunity to test the challenge designs with people in a (for most) new location, whom belong to a varied age group, do not know each other, and are in the city for a 2-day visit.

PARTICIPANTS

Of the 26 participants of the workshop, 14 people participated in the experiment: 6 women, and 8 men. The participants' ages were within the range of 25 to 62 years of age, and only 2 had been to The Hague before. Of the 14, 1 is a male full professor aged 62, 3 professors/researchers aged 35 (2 males, 1 female), 2 female researchers aged 31 and 32, 4 researchers aged between 28-29 (1 male, 3 females), and 4 younger male researchers aged between 25-27.

PROCEDURE

The gameplay was executed between two points A and B in the centre of The Hague, where A is the consortium's venue, and B the restaurant where all the participants had a joint dinner on the first evening of the event. Participants signed consent forms for data collection, and when possible installed the game on their own phones or phone provided (not all phones met the specific requirements of the game).

Participants were divided into 3 groups of up to 5 people with at least 2 smartphones with the game running per group. The geographical position of the 5 challenges provided the context of the activities involved. Each position was also marked by a facilitator whose task was to oversee and rate each team's performances. After 30 minutes of gameplay, the winning team was rewarded with free drinks at the restaurant.

METHOD

Each group was followed by one or two observers whom did not interfere with the gameplay. Each observer collected video recordings of his/her group's gameplay, for each challenge

[14] https://www.tudelft.nl/en/tpm/current/tmp-consortium/technology-management-policy-consortium/, Technology, Management and Policy graduate consortium, last visited on December 23, 2020.

and across all challenges. The three groups of participants, the 5 facilitators and 4 observers were interviewed at the end of the gameplay. The interviews were semi-structured, addressing what the participants thought of the game itself, their overall game experience, whether they had noticed any difference in social interaction resultant from having played the game and the challenges, and which challenges worked best. The results reported below are based on the transcriptions of these interviews. The transcriptions label all the participants as PX (being X the number of participant; e.g. P1, P5), and these labels are used when citing what a participant has stated. The video recordings are used to better understand both the gameplay and the feedback from the interviews.

Results

Game experience: In general, players said that the game experience was positive, it did not take much effort to play, the challenges were within a comfortable walking distance, the overall game mechanics of collaboration and meeting other people in and out of the group was appreciated, and that it was overall a repeatable experience. The challenges were reported to be good ice breakers and good to create experiences with people on the street that they can remember later on. They also mentioned enjoying particular challenges that had a nice themed description (for e.g., prisoners back in the era did...), as a powerful means to learn about the history of the place. They said that not all participants were as active as others (some refused to play certain challenges), and that leadership behaviour was noticed in some teams.

Challenges: Challenge 1 was reported to be a positive warming up experience that provided limited opportunity for communication. Challenge 2 was reported to be very positive because they were blindfolded and that it required a bit of imagination while still being achievable. Challenge 3 was reported to be weird, with the dancing and singing being too much. They said that role playing is nice and should be kept, but that more appropriate music, in line with the history of the place, should be used. Players thought challenge 4 was too difficult and frustrating. Challenge 5 was too easy to solve (mostly solvable within 10 seconds) and groups did not have strong opinions except that holding hands at that stage was already within their comfort zone. In general, they reported that themed challenges should be used. The use of rope in the challenge 2 was named as a prime example of disconnection between the places and the challenge. They also reported that two blindfolded challenges were too much, even though they felt comfortable performing these tasks.

Impact of game: Players recognise that the game with the challenges was designed for social interaction and that it did that. They argued that, if they would not have played the game, they would not have had the chance to talk as much as they did with other players. They reported that the gameplay forced them to collaborate, and that this provided them with circumstances to have natural conversations outside the scope of the game. They also reported that some of the activities ended up being fun, but that the overall experience could have been better if technical difficulties had not occurred. They also referred to a good build-up of the comfort zone within the group across the challenges: the first ones did not require touching but the last ones did.

Gameplay with/out smartphone: Team players without a smartphone with the game running reported a more frustrating and mixed overall experience than those with phones with the game. These players communicated a greater difficulty to participate, lower engagement, perceived the existence of bigger technical difficulties when reported by other players with the game as compared to the reports of the players that actually played (for e.g., "...every time we tried to do something, it was, like, it didn't really work..." (P5)).

4.2.4. DISCUSSION AND LIMITATIONS

This case study aimed to explore user requirements from the perspective of adults, and assess the efficacy of literature-based gaming activities in triggering social interaction in environments that are not-known to users. Social interaction was triggered with varying success through the developed prototype, and the lessons learned on the appropriateness of the applied challenge designs are now discussed.

TRIGGERED SOCIAL INTERACTION, LEVELS OF INTIMACY, AND LIKE-DISLIKE

The challenges were designed to promote participants' self-motivation to interact, by influencing their levels of intimacy (intimate face-to-face communication and quality of intimate topics shared). In and between challenges, players had plenty of opportunities to have natural conversations outside the scope of the game, which might have led to certain levels of bonding observed at the end of the gameplay. The order of the challenges proved to be relevant: challenges requiring intimacy due to specific requirements (e.g. blindfolds, touching other people, and dancing in public space) were built on top of previous interactions, which also helped to provide with circumstances to initiate dialogue. Results from the execution of challenge 3 show that, when players are faced with a task that demands too much intimacy, their degree of like-dislike is negatively affected and they end up not participating. It was observed and reported during the interviews that groups behaved friendlier and closer after the gameplay, being an anecdotal remark that a WhatsApp group was created with the participants of the winning team, which is something that would otherwise not have happened ("this happened because of the game" (P3)). The impact of the group's cohesion of the winning team was also observed through the act of taking selfies of the group when they were announced as the winners, which shows a certain pride and happiness in their overall performance.

BALANCE OF DIFFICULTY, AND PLAYER'S SKILLS

The challenges were reported to be good ice breakers and good at creating memorable experiences with people on the street. All groups commented on the high difficulty level of challenge 4, but none commented on how easy a challenge was (namely, challenge 5, where all groups took less than 10 seconds to solve). This resonates with existent literature advocating that a wrong adaptation of the difficulty of a game to players has a negative effect in them (Alexander et al., 2013; Qin et al., 2010), and raises the question on the level of difficulty that is most appropriate to facilitate social interaction and gradual participation and performance to occur. On the one hand, harder challenges might imply a bigger barrier for participation than easier challenges, but an easier challenge might fail to mediate observable face-to-face social interaction. On the other hand, a harder challenge does not necessarily imply lack of self-motivation to play, as all participants performed challenge 4 (allegedly the hardest) but not all of them performed challenge 3 (which has a lower level of complexity than challenge 4). Regarding players' skills, the degree of like-dislike seems to be affected by the players' perceptions of how good or bad they think they will perform, which could be observed by seeing certain players purposefully avoiding doing certain challenges that could be perceived as rendering them more exposed to the public eye (e.g. dancing).

Detective and Explorer: two types of gaming activities desired by users

Players mentioned liking particular challenges that had a nice themed description (e.g. challenge 3, presented in appendix B), with two particular reasons. The first relates to the willingness of participants to relate to their surroundings and understand its local history, which makes them learn about their unknown surroundings. The second reason mentioned by participants is the creation of scenarios that are motivating enough to make participants want to explore their physical location. This feedback from participants informs this research on what users would like to see in a game of this nature, with regard to gaming activities (content of the game). Therefore, this case study expands current understanding on users' requirements, of types of activities they want to have (i.e. linked to their surrounding's context)[15]:

> **Detective**: Detective type of challenges require finding information and answering questions about factual knowledge related to the surrounding environment. Players have to search for information in their neighbourhood, such as asking people about local heroes depicted in tiles in the footpaths in their neighbourhood.
>
> **Explorer**: Explorer type of challenges require players to explore their neighbourhood, i.e. by learning and comprehending more about their own neighbourhood and the people who live there. Challenges of this type might include discovering the origins of a neighbourhood. This type of challenge might lead a player to an unknown point of interest of the neighbourhood (e.g. an old building, a local initiative) and ask them to engage with random people to discover its origins.

These two types of gaming activities that the users from this case study mentioned are consistent with existent literature. Slingerland et al. (Slingerland et al., 2018) identified that *information about activities or places for activities* and *information about people from the neighbourhood* are very important for citizens to be proud of their neighbourhood, which gives intrinsic motivation for players to research and be detectives of information that is important in the context of the neighbourhood. They also argue that there are scenarios that are motivating enough to make citizens want to explore their neighbourhood, particularly the scenarios of *Social Engagement*, *Offering Help*, *Providing Tips*, and *Linking residents*. This goes in line with the challenge type Explorer, as it aims to make players go and explore what is happening around, engage with fellow neighbours about trivialities, and promote situations where social interaction can happen more easily.

Limitations

This case study was designed to explore how people attending a scientific conference would interact via, and because of, the created game prototype. The setting explored allowed to extract useful insights on the comfort zones people that do not know one another have, and their flexibility to change them during game play. The setting used provides a limitation to the motivation of this thesis, as the participants used do not live in the neighbourhood where

[15] This lesson learned is also included on the published article: G. Slingerland, X. Fonseca, S. Lukosch, and F. Brazier, *Location-based Challenges for Playful Neighbourhood Exploration*, Behaviour and Information Technology, doi: https://doi.org/10.1080/0144929X.2020.1829707, 2020.

they played the game. Participants were in The Hague for business, for a 2 day period only, and this could have served as either an extra motive for exploration of the physical environment, or as a hindrance preventing participants to care much about their surroundings and its local history.

Another limitation of this case study is the game prototype used, which could have been technically more mature to support the game play. One challenge was mistakenly placed inside a public building (a mall), which created technical difficulties in playing the game (no GPS coverage). Even though the number of participants is not statistically relevant, technical issues did affect the game play experience, and this was aggravated by those not having a smartphone with the game. This last point is also a limitation in itself, because not enough smartphones were available to provide participants with the same user experience. As such, a few participants used their own Android smartphones (with different technical specifications), and those participants not having an Android smartphone either used smartphones provided by researchers, or had to accompany other players with a smartphone capable of running the game. Due to this, participants reported different levels of engagement in the game simply based on whether they had a smartphone with the game or not.

Nonetheless, the case study was successful at exploring the users' preferences regarding a gameplay for social interaction in public space, and at creating situations where researchers could observe the behaviour of players and how it changed throughout the 5 challenges. Despite the identified limitations, the learnings are considered valuable.

SUMMARY

This case study explores the design of gaming activities, named challenges, to probe users in different ways of interacting, and understand their requirements from the perspective of adults. It uses 5 types of challenges guided by literature to probe how users react to the prepared gameplay, and, supported by an LBG prototype, it tested how individuals that know neither each other nor their location interact with the designed game activities. The results from the executed experiment provide insights on the appropriateness of the proposed challenge designs for the fostering of 1) self-motivation, 2) perceptions, norms and values, and 3) participation and performance between team members: they show that the overall experience of the players was pleasant, that there was a desire to keep playing these types of challenges and games in the future, and that levels of comfort were apparent during and after the gameplay, both between players and in regard to the challenges themselves. This indicates that the proposed challenges within the used game framework were appreciated and appropriate for these participants.

Regarding lessons learned, this case study discovers that the dynamics of play alone (found in chapter 4.1) are not enough to trigger social interaction in adults. The appropriateness of the design of each challenge is key to its success, and aspects such as 1) the balance of the difficulty level, and 2) the adaptation of the game play to the historical context of the location, must be taken into account to promote social interaction that users feel comfortable having in public space. This type of gameplay can be challenging to players not feeling comfortable with a given public exposure, and the wrong design for a game activity can have the opposite effect: players refusing to play the game. This lead to the proposition of two types of game activities that adults want to have, to relate to their context: Detective, and Explorer.

4.3. Case study 3: User requirements from Adults in The Hague

It seems like we're aiming at a child audience, but everyone can laugh at the basic human traits that are funny. It's playful, the humour is playful, the world is playful. You can kind of let go.

Stephen Hillenburg

Case study 1 explores the activities that adolescents prefer having in their neighbourhood, which motivates the challenge types Athlete (centred on physical activities) and Inventor (centred on creativity). Case study 2 focuses on adults, and describes a research design focusing on the appropriateness of gaming activities designed according to literature on interaction and cohesion. Its findings lead to two more types of challenges, the Detective and Explorer. The former is centred on retrieving information from people and the neighbourhood, and the later refers to the creation of scenarios that motivate the discovery of the neighbourhood.

This 3rd case study picks up on the findings on users' requirements regarding the type of activities (game content) that a location-based game should provide to promote social interaction in public space. It is designed to address one specific limitation presented in case study 2, which is the relationship between participants and their neighbourhood. It specifically investigates which type of location-based activities encourage citizens to interact with their neighbours and playfully explore their own neighbourhood, to explore how physical surroundings and their contextual information plays a role on social interaction. In this case study in the Hague (NL), a group of adults known to be interested in contributing to the livability and safety of their neighbourhood, participate in co-creating and game-playing sessions to explore their neighbourhood. It aims at further understanding if the types of challenges found in the case studies 1 and 2 (i.e., **Athlete**, **Detective**, **Explorer**, and **Inventor**) hold, or if these change in some way. To do that, two workshops are held: one, to have participants play the existent 4 types of gaming activities, and another, for participants to co-create activities that they want to have for their own neighbourhood. For the first workshop, the game prototype used for case study 2 was further developed to accommodate the types of challenges found in the case studies 1 and 2, and to offer more robust game play sessions based on these types of challenges that users mentioned wanting to play (both adolescents and adults). The challenge designs explored in the first workshop are tailored to a specific neighbourhood, and are meant to be played by citizens living in that environment. The second workshop enables citizens to inform this research on what they require for gaming activities, and the reasons for their preferences.

This chapter is based on the published article: G. Slingerland, X. Fonseca, S. Lukosch, and F. Brazier, *Location-based Challenges for Playful Neighbourhood Exploration*, Behaviour and Information Technology, doi: https://doi.org/10.1080/0144929X.2020.1829707, 2020.

4.3.1. CONTEXT OF THE CHOSEN NEIGHBOURHOOD

This case study took place in Bouwlust (a neighbourhood in The Hague, within the district of Escamp, with over 100.000 inhabitants). This neighbourhood once started as an upper-class area for civil servants, but has gradually transitioned into an area with livability and safety issues with significant numbers of burglaries and above average drug related crimes and abuse. Many households are low-income (with a minimum income) and about 70% of the residences is in social housing (Haag, 2017). In the last decades, many residents from outside The Netherlands migrated to this neighbourhood, currently representing almost 60% of the inhabitants. The neighbourhood is, thus, very diverse.

Despite its issues, this neighbourhood has several (volunteer) citizen initiatives ongoing, some financially supported by the city, some not. The community centre, for example, organises many activities as do more local 'neighbourhood living rooms'. Residents also organise themselves based on ethnicity. The Turkish community, for example, comes together on Saturdays to eat together and sing traditional songs. Representatives of these ethnic community groups hold monthly meetings, to find ways to connect the various cultures to one another, aiming for a more cohesive community.

The number of initiatives and small citizen community groups within Bouwlust indicate that citizens are interested in contributing to a safer and more liveable environment. They use Whatsapp and Facebook groups to share information. However, these efforts remain only visible in the digital space for those who are connected. They do not make use of the physical environment. This case study investigates the potential of a location-based game in this context, to couple digital and face-to-face interaction, and to connect these activities to the physical locations of the neighbourhood.

4.3.2. EXPERIMENT DESIGN

To study which type of challenges are preferred for social interaction two consecutive workshops were organised at the community centre in Bouwlust, using the location-based game prototype mentioned in case study 2, and modified to offer the 4 types of challenges found in the two previous case studies. Table 4.4 shows what was done in each of the workshops. During the first workshop, participants play tested the game with challenges designed by the research team, presented below. All participants were given a smartphone on which the game was pre-installed. During the second workshop participants were asked to design their own challenges based on their experience of playing the game. The detailed workshop procedure, participants, and methods for data collection and analysis are further described in the next sections.

Date	Workshop	Activity	Collected data
24-01-2019	Workshop 1	Play testing SotS with pre-designed challenges, debriefing.	Observations, debriefing notes, SUS questionnaire, survey.
31-01-2019	Workshop 2	Brainstorming challenges, presenting and discussing the outcomes.	Audio recordings of workshop, challenge designs.

Table 4.4: Two workshops with participants construct the main part of this research.

RESEARCH METHODOLOGY

The purpose of this research is to identify what activities citizens prefer in a location-based game that fosters social interaction. Therefore, the leading research question is: What kind of location-based activities do citizens prefer for social interaction and to playfully explore their neighbourhood? Research through design (RtD) (Zimmerman et al., 2007) is used as a methodology, as the answer to this question cannot be devised rationally, but needs to follow from constructive design research in the field (Koskinen et al., 2011). RtD supports a holistic perspective (Zimmerman and Forlizzi, 2014), and uses methods and processes of design practice to generate new knowledge (Zimmerman et al., 2007). The knowledge generated in this study is related to the preferences of citizens for certain types of challenge activities which foster social interaction. This knowledge needs to come from the citizens themselves and consequently, co-creation (Brooke, 1996) is a fundamental approach throughout the research. Co-creation sessions allow researchers to acquire knowledge on the tacit and latent knowledge of participants, which represents what they know, feel, and desire (Brooke, 1996). The next sections describe how citizens first play tested the game to understand its possibilities, and during the second session were invited to co-create their own challenges. By enabling citizens to become participants in the design of the game, a deeper understanding is acquired on what citizens prefer as challenge activities and the reasons for their preferences.

CHALLENGE DESIGNS

Five challenges were designed in advance for the case studies. These challenges were designed to give participants an impression of the types of activities that could be performed within the game, in line with the four types of activities mentioned above:

- **Challenge 1 - "Make the neighbourhood yours"**: Players are asked to pretend that the municipality would like to build a museum focused on their neighbourhood, physically positioned within their neighbourhood, and that they have been asked to provide information on their neighbourhood that needs to be considered. They are asked to collectively think about and discuss characteristics of their neighbourhood, to create a word cloud and/or drawings on a sheet of paper. Their 'artworks' will be put to vote, and the names of the authors of the winning ideas will be mentioned in the fictitious museum. As part of the challenge, at the end, all players see the other players' creations and together decide which is best by voting.

  This challenge is of the type Inventor as it fosters creation of something for the neighbourhood museum by working together - in this case a word cloud or drawing. This challenge invites participants to reflect on their perspective of the neighbourhood and the views of others during and after the creation process.

- **Challenge 2 - "Discover your neighbourhood"**: In this challenge, players are asked to find a specific point of interest to complete this challenge: de Buurtkamer (the 'neighbourhood room'). They are asked to walk to this location to answer some quiz questions about the location, namely 1) What types of activities are possible at this location - what could a neighbour be doing here?, 2) Can a neighbour also organise something him or herself?, and 3) Who should a neighbour contact to find out more?. Answers can be discovered either by talking to someone in de Buurtkamer, or, if this is not an option, by finding QR codes posted outside for this purpose (when QR codes are scanned, answers are provided, and points attributed).

This challenge is of the type Detective. Questions are asked about what can be done at a specific location in the neighbourhood, specific people need to be found, and the information asked might be new to the players.

- **Challenge 3 - "Interview your neighbours"**: This challenge seeks to find out more about a neighbourhood by asking players to explore the best places in their neighbourhood. Players are requested to ask five people on the streets about their favourite places in the neighbourhood. Pens and papers are handed out, so that people's responses can be written down.

  This challenge is of the type Explorer. The question is open, without a clear or correct answer, and seeks to make players discover the best places in their neighbourhood, requiring orientation and exploration.

- **Challenge 4 - "Photo story"**: Players are asked to make a photo story of the rhythm of their neighbourhood. They are asked to take pictures of their daily routine, and to illustrate the life rhythm of their neighbourhood. When do people go to the parks or do their groceries nearby? They are asked to document what happens around them. This challenge is also of the type Explorer.

  This challenge is very open, players are free to focus on activities of their choice: they can take pictures of activities in parks, cars, buildings, schools, of people, animals, and anything else of interest in their exploration of their neighbourhood.

- **Challenge 5 - "Get to know each other"**: Players are asked to first think about characteristics of their neighbourhood. One word from the winning word cloud from Challenge 1 is chosen, all participants are blindfolded, and asked to represent that word using a piece of rope. This exercise is done by all teams together, facilitated by mediators (to guarantee safety), requiring collaboration to solve this challenge. Rewards are awarded on the basis of quality of performance.

  This challenge is of the type Athlete. Players have to physically work together and collaborate to solve the challenge (shaping the rope while blindfolded).

The above five challenge designs are designed to potentially enable different types of behaviour to increase social interaction, while doing so in a playful manner. Players are required to interact with each other and with others on the street. The first challenge is an introductory challenge designed to introduce players to each other and to think creatively about their neighbourhood. Challenges 2, 3 and 4 are designed to expose players to the people and public spaces in the neighbourhood through out-of-ordinary dynamics that enable them to engage in a playful way, to discover more about their neighbourhood, its rhythm and activities. Lastly, challenge 5 aims at bringing players together to foster social interaction between them, both via physical contact, communication face-to-face, and playful interaction.

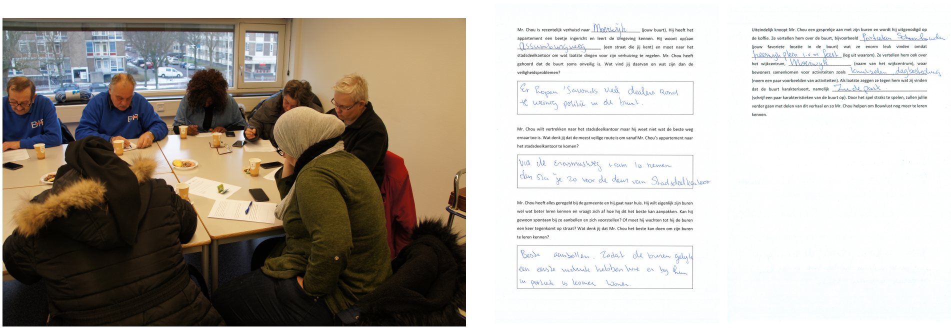
Participants

The only requirement for participation in activities organised in the community centre in Bouwlust, during the past two years and in the context of the joint effort between the Municipality of the Hague and TU Delft's research group, has been that citizens are interested in improving their neighbourhood and contributing to its livability and safety. A citizen network has emerged with approximately 45 participants. Participants for the two workshops were recruited from this network.

Each member of this network was invited to two workshops, either in person, by phone, or email. In total, ten citizens agreed to participate of whom seven (five female, two male; age group 36-75 years) actually attended the first workshop, four (two female, two male) of whom also attended the second. Unfortunately, the second workshop had fewer participants due to unexpected time constraints, and severe weather conditions. The workshops focused on co-creation and game-play.

Workshop 1: Play testing

The first workshop held in January 2019. Participants were introduced to the research challenges and the workshop schedule. They were also requested to formally provide informed consent for participation in this research project and use of experimental data acquired. To start, all participants were handed a story about a new resident in the neighbourhood with gaps that participants were asked to fill in as an activity to warm them up for the game play that followed (see figure 4.4).


Mr. Chou is recentelijk verhuisd naar Moerwijk (jouw buurt). Hij heeft het appartement een beetje ingericht en leert de omgeving kennen. Hij woont op/aan Assumburgweg (een straat die jij kent) en moet naar het stadsdeelkantoor om wat laatste dingen voor zijn verhuizing te regelen. Mr. Chou heeft gehoord dat de buurt soms onveilig is. Wat vind jij daarvan en wat zijn dan de veiligheidsproblemen?

Er lopen 's avonds veel dealers rond te weinig politie in de buurt.

Mr. Chou wilt vertrekken naar het stadsdeelkantoor maar hij weet niet wat de beste weg ernaar toe is. Wat denk jij dat de meest veilige route is om vanaf Mr. Chou's appartement naar het stadsdeelkantoor te komen?

Via de Erasmusweg tram 16 nemen dan sta je zo voor de deur van Stadsdeelkantoor

Mr. Chou heeft alles geregeld bij de gemeente en hij gaat naar huis. Hij wilt eigenlijk zijn buren wel wat beter leren kennen en vraagt zich af hoe hij dit het beste kan aanpakken. Kan hij gewoon spontaan bij ze aanbellen en zich voorstellen? Of moet hij wachten tot hij de buren een keer tegenkomt op straat? Wat denk jij dat Mr. Chou het beste kan doen om zijn buren te leren kennen?

Beste aanbellen. Zodat de buren gelijk een eerste indruk hebben wie er bij hun in portiek is komen wonen.

Uiteindelijk knoopt Mr. Chou een gesprekje aan met zijn buren en wordt hij uitgenodigd op de koffie. Ze vertellen hem over de buurt, bijvoorbeeld Portieken Schoonhouden (jouw favoriete locatie in de buurt) wat ze enorm leuk vinden omdat Moerwijk plein i.v.m feest (leg uit waarom). Ze vertellen hem ook over het wijkcentrum, Moerwijk (naam van het wijkcentrum), waar bewoners samenkomen voor activiteiten zoals knutselen, dagbesteding (noem een paar voorbeelden van activiteiten). Als laatste zeggen ze tegen hem wat zij vinden dat de buurt karakteriseert, namelijk Zuiderpark (schrijf een paar karakteristieken van de buurt op). Door het spel straks te spelen, zullen jullie verder gaan met delen van dit verhaal en zo Mr. Chou helpen om Bouwlust nog meer te leren kennen.

Figure 4.4: Participants working on the warm up exercise inside the community centre (left) and one of the warm-up stories filled in (right).

Workshop 2: Designing challenges

The second workshop held a week later focused on designing challenges. Using simple brainstorm exercises, participants were asked to design challenges for their neighbourhood. Participants were first asked to do a brain-writing exercise to think about different elements for challenges: such as locations, interactions, and activities. Table 4.5 shows the questions and triggers used in this exercise. Participants had five minutes for each question.

After a short break, participants were split up in teams of two to design challenges based on the different elements they generated in the previous exercise. Each team was handed

Figure 4.5: Participants discussing their daily rhythms during the Photo story challenge.

Brainstorm Question	Triggers used
Which locations in your neighbourhood would be appropriate to play a challenge?	Maps of neighbourhood
What things do people like to talk about?	Pictures of neighbourhood
What do you know about the history of the neighbourhood?	No triggers used
How can people interact with each other on the street?	Pictures of neighbourhood
What activities are happening in the neighbourhood?	Pictures of neighbourhood

Table 4.5: Brainstorm questions and triggers.

sheets of paper that contained several boxes with which the game elements in a challenge could be described, see figure 4.6.

These included: challenge location, type of interaction players are to pursue while playing the challenge, type of challenge, which information is to be shared while playing the challenge, and the challenge activity. Participants were given 20 minutes to design challenges after which they presented their designs to each other. The workshop ended with a brief discussion amongst participants about their challenge designs:

- Why and how did the participants interact with each other and the neighbourhood while playing the game?
- Which type of challenge activities are preferred by the participants (and why)?
- Which physical elements in the neighbourhood (locations/objects/people/etc.) are considered by participants to be fruitful for exploration?

Two researchers independently reviewed the data and marked data fragments relating

Figure 4.6: Participants working on their challenge designs.

to the questions. Each fragment was coded independently and compared. The researchers discussed differences between their codes and jointly decided to add, remove, or re-code a data fragment when both researchers agreed. They collaboratively defined meaningful clusters of codes, and clustered the codes to address the main research question.

4.3.3. RESULTS

The following sections describe the *challenge types and activities* participants considered for playful social interaction, the *physical elements* in the neighbourhood that stimulated exploration, and the *types of interaction* participants preferred for exploring their neighbourhood.

Note that although there were only five challenges and teams were free to choose which of the challenge they played (after the first) not all challenges were played by all teams. In fact, the Photo Story challenge was the only challenge played by all teams. The challenge Discover Your Neighbourhood was played by two teams. The Interview Your Neighbours challenge was played by only one team. Participants all played three of the four different types of challenges (Detective, Explorer, and Inventor) during the workshops.

CHALLENGE ACTIVITIES FOR PLAYFUL SOCIAL INTERACTION

Data from the open question survey, observation notes, and the challenges participants designed themselves provided insight into which kinds of challenge activities participants considered for social interaction, and believed that can foster it.

A. Discovering the neighbourhood
All of the challenges designed by participants involved discovering the neighbourhood. For example, one challenge design guides citizens towards particular landmarks in the neighbourhood and the challenge is solved by hunting down these landmarks and scanning QR codes to be placed to this purpose. The purpose of this challenge was, according to its designers, to *"show what things are around in our neighbourhood"* (P3, P4; workshop 2). Such preference for enabling others to discover their neighbourhood was also reflected when participants were playing the game: in one of the teams, one participant (P3, workshop 1) spontaneously started to show the other two around the area, telling them stories on the shops that used to be there and how the neighbourhood had developed over the years.

B. Preference for familiar technology
During the gameplay and challenge co-creation sessions, all participants indicated a preference for technology with which they are familiar, above pen and paper writing. Participants had access to different means of with which to support exploration of the neighbourhood within gameplay. They could scan QR codes, take pictures, write text into the game, discuss amongst each other, or use pen and paper to write and draw. When designing their own challenges, all four participants chose to use QR codes (used in two challenge designs) or pictures (used in three challenge designs) to solve challenges, and two challenge designs proposed writing text in the game to answer questions. However, face-to-face discussion or pen and paper writing were not preferred by participants. These ways of sharing information about the neighbourhood were not considered to be engaging, as reflected in the observation notes. When playing the 'Make the neighbourhood yours' challenge, for which participants needed to create a word cloud about their neighbourhood on paper, all teams were *"taking the task very seriously"* (observer 2) and *"divided the tasks amongst team members"* (observer 1 and 3). They did not express behaviour that indicates fun, such as laughing, nor did they interact a lot while solving this challenge.

C. Relevance of sharing information
The challenges participants played allowed them to share information about the neighbourhood in different ways. In the survey after the gameplay, one participant indicated that sharing information *"broadens her horizon"* (P1, workshop 1). One observer noted that participants discussed mutual problems, such as street youth, and possible ways of solving these problems. In the challenges participants designed themselves, the information required to be shared was about specific landmarks or stories about a location or object in the neighbourhood. For example, two participants (P1, P2; workshop 2) designed a challenge for which players needed to discover the meaning behind street names. One participant (P2, workshop 2) also mentioned that stories on the development of the neighbourhood are potentially interesting to be shared. The stories told by participants were, for example, about where the city used to end and how the city has gradually 'stolen' land to expand. All four participants (workshop 2) seemed to find stories that include a kind of controversy interesting for challenge activities.

D. Designing challenges with purpose
When participants presented their own challenge designs to each other, it became clear that

they had designed each challenge with a particular purpose. They deliberately designed challenges to acquire input from their neighbours on a local topic (one challenge design, P3, P4; workshop 2), bring a certain issue to the attention of residents (one challenge design, P1, P2; workshop 2), or stimulate a discussion amongst neighbours (one challenge design, P3, P4; workshop 2). The explanations participants provided in the survey on what they liked about the game and why showed that participants enjoyed challenges that connected to their daily life. This was notable in the Photo Story challenge, in which observers noted that one team was very engaged and having fun in discussing their daily rhythm and taking pictures to document this rhythm, while another team did not enjoy this challenge because it was not at a location they usually frequent, and thus not connected to their daily life.

PHYSICAL ELEMENTS IN THE NEIGHBOURHOOD

This section describes the locations and objects in which participants expressed interest to explore, and the information they wished to share about these places.

A. Locations

In addition to naming specific locations in their neighbourhood, such as religious buildings, schools, or playgrounds, participants also named necessary characteristics of such locations. Participants mentioned several preferences regarding the proximity and distribution of challenge locations: even distribution throughout the neighbourhood, but also close to the centre. Challenge locations need to be close to each other, for those whom are less mobile to be able to play (P2, workshop 2) and to enable multiple challenges to be solved within a short time frame (P1, workshop 2).

Social locations, where activities happen and people gather, were also named specifically. For example, one challenge design was created by participants to be played at 'De Uithof', because *"there are many activities being organised there"* (P1, P2; workshop 2). For these locations, the two participants expressed that a good atmosphere is important. One team (P3, P4, P5; workshop 1) discussed that their preference for a specific community space to drink coffee and meet neighbours was solely determined by this factor. The other factor that influenced choice of locations was their aesthetic appearance, such as parks or streets with beautiful trees around. One participant stated that *"there are only beautiful streets in our neighbourhood"*, and that it is kind of a *"tree museum"* when you walk around (P3, workshop 2).

B. Objects

Objects in the neighbourhood that are considered to be appropriate for exploration are mainly landmarks. Often, the suggested landmarks are related to the historical development of the neighbourhood or they are suggested because they are simply remarkable in their design or location. Landmarks suggested by participants were, amongst others, bridges, statues, or historical landmarks. The latter is not necessarily interesting due to the object itself, but rather because of the story that can be told about this object. For example, one participant (P4, workshop 2) told the group about two milestones that were placed in the neighbourhood, to mark the history of the Roman Empire, and that this specific place had once been in Roman hands.

C. Sharing information about physical elements

Interestingly, all four participants (workshop 2) proposed challenges related to information sharing connected to a physical location, although the physical location itself was not necessarily of significance. For example, participants discussed how information about activities in the neighbourhood, stories and initiatives could be physically distributed in the neighbourhood, using a specific challenge. They also discussed the use of other types of media such as a local newsletter that could be used to this purpose (not necessarily related to the game). These spontaneous discussions indicate that participants had a high need for information in their neighbourhood, and that currently a solution for sharing information is lacking.

INTERACTION LEADING TO EXPLORATION

The game play supports several types of interaction and players are free to choose which type of interaction they apply to solve challenges. The way participants, thus, interacted while playing the game provides insight in their preferred type of interaction. The data also indicated that specific types of interaction and behaviour were triggered by the game.

A. Enjoying natural conversations

All seven participants (workshop 1) enjoyed natural conversations with other citizens, who were not necessarily participating in the game, during gameplay. Participants interacted with their teammates and people on the streets. They engaged in natural conversations with them, by asking questions or simply talking to them. In the survey, participants mentioned that they enjoyed meeting people (all participants; workshop 1) and interacting with them during the game play (P1, P5, P6, P7; workshop 1). The same can be concluded from the observation notes. Interactions with familiar people, such as their teammates, were experienced as bonding with friends, while greeting and talking to strangers was perceived as a way to create useful contacts. When visiting the Buurtkamer, for example, four participants (P1, P2, P6, P7; workshop 1) promised the representative of the Buurtkamer to come again and join one of the activities in the near future.

B. Collaboration

Participants worked in teams to solve the challenges, so collaboration was an important part of the game play. Participants were also able to take on different roles, such as the leader, during the game play. In the survey, three participants (P2, P5, P7; workshop 1) explicitly mentioned that collaboration was important to them and that they enjoyed this about the game. However, not all challenges necessarily required interaction according to the participants. Some challenges were solved rather independently, some by dividing the tasks. Nonetheless, in the challenges participants designed themselves, they indicated that teamwork and collaboration were important aspects.

C. Lowering the barrier to interact

For some participants (P1, P6, P7; workshop 1) the game activities lowered the barrier to interact, as they engaged with strangers on the streets. They greeted strangers while playing the game or interviewed them about their favourite place in the neighbourhood to solve one of the challenges. Some of them did this naturally, while for others the boundary was lowered due to the gameplay. One participant mentioned in the survey: *"Apparently for me the threshold to just walk in, and ask what they are doing and if I can join in, is high"* (P1; workshop 1). This indicates how the game has the potential to stimulate social behaviour and interaction.

USABILITY OF THE GAME

The results so far mainly describe how participants behaved in the gameplay and which activities they enjoyed. As the game used was a prototype, the usability might have influenced the experience of participants. The resulting average score for the SUS questionnaire after playing the game (although not significant due to the low number of participants) is 62, and 68 is considered to be an indication of generally good usability (Brooke, 1996). The paragraphs hereafter describe the two usability issues observed.

Even though not all participants, especially the ones belonging to the age group of 65+, were proficient with a smartphone, but in general they navigated through the game without help. All participants were able to find the list of challenges, open one, and to start navigating to its location. However, each team member had his/her 'own' phone with the game and the phones did not always show the same distances or directions to the required location, causing confusion within teams. All teams fixed this by just focusing on one phone to not allow further disturbance of the gameplay. The precision of the GPS receivers in the phones were the cause of the differences.

A second issue occurred when participants arrived at a challenge location and the challenge on the phone did not open because their GPS location was not close enough to the predetermined coordinates. This led to some frustration. This also distracted participants from engaging with the neighbourhood, as one observer noted: *"This player is mainly engaged in figuring out why the game is not working, even though I told her multiple times to just join the discussion and use the other player's phone to answer the questions. However, she kept on focusing on the phone and did not engage in the discussion with the Buurtkamer coordinator"* (observer 1). Despite these two usability issues, the conclusion that participants generally understood how to use the game and their experience was not severely impacted, seems warranted.

DISCOVERY THROUGH LOCAL INFORMATION SHARING

The theme of *Discovery through local information sharing* seems to be intertwined through all results: It plays a role in challenge activities, physical elements, and interaction. Participants can become motivated to explore the neighbourhood with the expectation of discovering an interesting location or story they do not know about. The workshops show that participants became very engaged with the game when they were learning new things, whether it was getting to know new people or stories on how the neighbourhood developed. Their curiosity was triggered during the game play; participants came up with questions themselves rather than following the game questions.

Considering everything that participants said and that was written in the observation notes, participants seemed to have enjoyed activities in which they share information about their neighbourhood. They told stories or presented interesting locations which they feel other citizens should know about. When discovering new locations themselves, as for example required for the challenge with the Buurtkamer during the workshop, participants became very excited, as reflected in their responses in the open survey (six participants named this explicitly) and the observations made. This illustrates that *discovery* is something participants highly valued and appreciated in the gameplay.

One crucial element for discovery in the neighbourhood is local information. The purpose participants assigned to challenges are related to stimulating information sharing: either about a particular local issue that needs awareness, or an interesting activity that is being organised but not many people know about. It is clear from these suggestions that currently, there is a lack of information sharing in the neighbourhood and participants would like to change this.

However, the results express a paradox related to familiarity in the neighbourhood, which links to social interaction. On the one hand, participants want to play at a location they do not know yet to discover new things. On the other hand, they want to engage with citizens from their own neighbourhood, and want locations to connect to their daily lives. This paradox was illustrated in the Photostory challenge, when one team did not enjoy this challenge because they were not at a location they usually frequent. This is similar for the familiarity of people that participants play with: they enjoy to be in teams with people they know, but also really like to meet new people during the game play. This illustrates the necessary balance that needs to be found between familiarity and discovery.

4.3.4. Discussion and Limitations

This case study picked up on previous findings on users' requirements regarding the type of activities that a location-based game should provide to promote social interaction in public space, and further explored the potential use of LBGs for this purpose. It investigated which types of gaming activities are preferred by citizens to interact with their neighbours and playfully explore their own neighbourhood, and learns that 1) discovery of the physical environment needs to be balanced with familiar elements; 3) collaboration is important to users; and 3) not only the 4 tested types of gaming activities hold, but that 3 more emerge.

Discovery versus familiarity

The preferences of citizens for location-based activities creates a paradox for design: citizens want to discover new things at places that are familiar. Designing a location-based game for social interaction in public space involves neighbourhood exploration, and it needs to put discovery as a strong element in the game play. Citizens expressed, both verbally as through their behaviour, that they enjoyed exploring locations in their neighbourhood which they had never visited before, they liked to get to know new people from their neighbourhood, and they took pleasure in hearing novel stories about their neighbourhood. This insight resonates with previous work, although there the focus was on learning as a motivator for participation, not stressing discovery specifically (Robertson and Simonsen, 2012). In the research of (DiSalvo et al., 2008), for example, citizens used simple sensing robots to explore their neighbourhood and became more engaged with the project when they started to acquire new insights on their neighbourhood, like the high sound levels of cars at a certain crossroad, based on the data they collected with the sensing device. Discovering what is happening in the neighbourhood and what are the so-called matters of concern (Bjögvinsson et al., 2012) is a motivator for citizens to engage and become active (Erete, 2015; Gooch et al., 2018). This insight, specifically, is supported by this research as well.

Discovering experiences can be facilitated by distributing challenges in areas known to players, as well as areas they do not often frequent. For this to happen, game designers or researchers need to understand which areas and locations are familiar to players, to make a good distribution of challenge locations. This interplay between design and the environment around it is also acknowledged by others (Cila et al., 2015; Ehn, 2008). Location-based activities for social interaction in public space can, therefore, not be designed without taking the surrounding neighbourhood into account. The locations need to be appropriate for the designed activities and be relevant for the citizens who will engage with them (Kuijer et al., 2013). It is, therefore, vital that researchers and designers engage with citizens of the neighbourhood through extensive field research, to understand which challenge locations and activities are appropriate for the specific context for which groups of citizens (Kendall and Dearden, 2018).

Even though citizens can be motivated through the promise of discovering new places, people, and stories, citizens do not like to explore a place that is completely unfamiliar and unrelated to them. This finding corresponds with previous work (Papangelis et al., 2017), in which participants reported that playing at locations they connect with is more meaningful than places they had never seen before. People have different ways of connecting to places (Friedmann, 2010; Pink, 2008) and this research revealed that citizens connect through the frequency of visiting a place. Therefore, it supports earlier findings that citizens prefer to play in areas and teams that are familiar to them and connect to their daily life.

4

Collaboration as an important game dynamic

The location-based games and other urban playful experiences that were reviewed in the literature review (chapter 3), show a dominance of using a competitive dynamic in the game play (e.g. (Clark and Clark, 2016; Hodson, 2012; Papangelis et al., 2017; Peitz et al., 2007; Pyae et al., 2017; Sotamaa, 2002). Collaboration and cooperation as game dynamics were used in previous research, for example in Epidemic Menace (Fischer et al., 2007). In this game, players had to collaborate as a team and compete against other teams in finding who released the virus. They reported they enjoyed communicating and working in pairs while competing with the opposing team. Players indicated cooperation as a positive element of the gameplay, which corresponds with the results from the current study; namely that citizens have a strong preference for challenge activities based on collaboration.

Citizens expressed that collaboration in their neighbourhood community is important to them, and specifically designed challenges for which players need to work together to be solved. The games discussed in the background mainly use the game dynamic competition and not collaboration, though it plays a major role for building citizen communities (Collins et al., 2014; Y.-C. Kim and Ball-Rokeach, 2006; McMillan and Chavis, 1986; Nicotera, 2008; Slingerland et al., 2019). For such communities to thrive, citizens need to experience that they can work together and achieve something. This research further shows that citizens prefer collaborative activities if they jointly explore the neighbourhood in a playful way. Consequently, game activities that aim to support social interaction in public space require to use collaboration as a game dynamic, for citizens to be motivated to play.

Hunter, Artist, and Volunteer: Three new types of gaming activities

Three new challenge types are proposed based on the challenges citizens designed themselves as part of this research. Citizens deliberately came up with challenges that served a particular purpose. These challenges differ from the current challenge types in the kind of behaviour they prompt from players. However, all aim to foster social interactions with people on the street or learning about the neighbourhood and its stories. The three new types of challenges proposed by the participants in this study extend the current classification with four challenge types to include:

> **Hunter**: The behaviour elicited by this type of challenge is linked to finding specific type of people or objects, as opposed to finding random people. Hunter is about finding tangible things that can be human, animal, or an object. For example, finding the person responsible for the community centre to ask what types of activities can be done there. If and when such people cannot be found at a given time, players can find ways to still address the challenge (e.g. finding a QR code attached to the community centre explaining exactly what they would like to ask the person).
>
> **Artist**: This type of challenge requires players to design artwork in and about their neighbourhood, based on creative processes individually or collaboratively. Such artwork might be abstract and personal or collective, and represents a creative expression about the player's neighbourhood. For example, creating a song or musical performance (rapping), writing a poem, or storytelling.
>
> **Volunteer**: This type of challenge invites players to contribute towards the community, and incites behaviour to help others or contribute to the quality of life in the neighbourhood. An example of a challenge of this type is picking up trash at a specific location to make a nice piece of art with it, and taking a picture of it to publish in the media of the local community, before the trash is collected.

These three challenge types, together with the other four (*Athlete*, *Detective*, *Explorer*, and *Inventor*), are all desired by the participants, and ask for different type of play behaviour and interaction to solve a challenge. They require players to do physical activities (*Athlete*), find information and factual knowledge (*Detective*), explore the neighbourhood (*Explorer*), propose ideas and explore opportunities (*Inventor*), find specific things or people (*Hunter*), create and express thoughts, feelings, interests in some form (*Artist*), and contribute to the environment and help others (*Volunteer*).

Limitations

This case study comes with some limitations regarding the generalisation and applicability of the findings. It is based on one location only (The Hague, The Netherlands). Even though the effort to involve as many citizens as possible, and to have a group of participants that is representative of the chosen location, the participant sample was small and not representative for the neighbourhood. The majority of participants in the first workshop were women, and in the second workshop both male and female genders were equally represented. Diversity in ethnic background, age, and therefore the preferences of these non-represented citizens is not accounted for. Nonetheless, measures were taken to ensure credibility of the work. This study applied triangulation regarding researchers, and regarding data collection. Researcher triangulation was achieved by having three different researchers observing the teams playing the challenges. Triangulation regarding data collection was achieved by having two researchers independently coding the data resultant from the workshops. The results are, therefore, considered trustworthy and can be transferred to other neighbourhoods that are similar to the presented case study area.

Further research is needed to explore the applicability of this study in locations not similar to the presented case study. Similar studies in different locations could render different results due to different social rhythms, norms and values of both individuals and communities. However, the results reported in this study are still considered to be relevant. The reported types of challenges are considered to be stable, as they are not solely based on this study.

New questions and future work

Several guidelines were identified in this study on how to playfully foster social interaction throughout the neighbourhood. These findings also lead to new questions and thus challenges for future work. The first finding states that discovery is an important motivator for citizens to explore their neighbourhood. Discovery is something that can be done only once per location, person, or story. Accordingly, the question pops up how discovery needs be to be addressed on the long run. For example, can players re-do challenges, for which every time they discover more details about a place or story? Research of, for example, Jones et al. (Jones et al., 2019) shows that this is an option: games can facilitate reflection on a familiar place to support discovery of new meaning. Another option could be to allow citizens to add challenges, that entail discovery, themselves, and this would acquire citizens to know which places might be interesting to be discovered by others. Hence, one challenge that needs to be addressed in future work is how discovery in the game can be addressed on the long run.

This case study shows that discovery needs to be balanced with familiarity, to make sure the items that are discovered relate to the daily lives of players. That this is complex was shown during the workshops. Participants had different levels of familiarity with areas in the neighbourhood in which the game was played, but this did not directly impact their engagement during gameplay. This means that also other factors played a role, such as the challenge activity or personal interests. Hence, for certain types of challenges discovery may be more important as a motivator than for others. This balance needs to be explored further in future research, because this research only identified some indicators of this balance, but not how it exactly should be manifested. In general, future work could focus on exploring these mechanics as well as scaling the research up by involving more participants and from a wider age group.

Three new challenge types were proposed as a result of this research. Future work should investigate whether these challenge types are able to foster social interaction, and whether they are preferred by citizens to be played with this purpose in mind. The challenge types can be related to the work of Bartle (Bartle, 1996, 2005) on player types, describing roles often seen in games that evoke social play (Bartle, 1996; Salen et al., 2004). The challenge typology can also be associated with the player traits and characteristics described in other research (Tondello et al., 2019; Tondello and Nacke, 2019). A direct overlap between these preferences of players and the challenge types cannot be found, possibly because they are based on virtual or pervasive games respectively. Future research could, however, investigate the relationship between player traits and the proposed challenge types, to create a coherent and consistent classification of challenges for social interaction in public space.

Summary

This case study examined the types of gaming activities that a location-based game should provide to promote social interaction in public space. It asks the question: *What kind of location-based activities do citizens prefer to interact with their neighbours and to playfully explore their neighbourhood?* Two workshops were organised in the Hague in which adults played different gaming activities (challenges) on an LBG prototype, and then designed their own challenges for this game. The challenges designed for the first workshop were successful at triggering natural conversations, make participants collaborate, and be exposed to the barrier of public interaction. After the co-creation session in the second workshop, lessons learned include:

- A classification of 7 different types of location-based activities (4 previously found and strengthened in this case study, and 3 newly found in this case study);
- Citizens prefer playing challenges in which they jointly discover something about their neighbourhood, such as a location or an activity, but that these discoveries, in order to be engaging, need to relate to their daily lives;
- Collaboration is an important game dynamic for stimulating exploration and interaction, while many current games for this purpose are based on competition;

Game designers and researchers can use these findings as a guidance in creating playful experiences aimed at fostering social interaction in the future.

4.4. Case study 4: Understanding adolescents' preferences for co-located social interaction via co-design

It's sort of a mental attitude about critical thinking and curiosity. It's about mindset of looking at the world in a playful and curious and creative way.

Adam Savage

4

Case studies presented so far on user requirements (in sections 4.1, 4.2, and 4.3), for location-based games (LBGs) designed for the promotion of social interaction in public space, argue that there are 7 types of activities that users want to play with such games within their neighbourhood. Research done with adolescents (section 4.1, (Fonseca, Lukosch, Lukosch, and Brazier, 2020; Fonseca et al., 2017)) informs that activities of the type *Athlete* and *Inventor* are of specific interest to this target group: gaming activities that require physical exertion to solve the proposed task (*Athlete*) and activities that require creative solutions (*Inventor*). In the next phase of this research, adults were consulted. Adults showed interest in a broader scope of activities in their neighbourhood (sections 4.2 and 4.3, (Fonseca et al., 2018a; Slingerland, Fonseca, et al., 2020)): *Detective*, *Explorer*, *Hunter*, *Artist*, and *Volunteer*. Gaming activities designed based on *Detective* invite players to search for factual knowledge of the environment; those based on *Explorer* require players to explore any information of their neighbourhood by engaging with it and with random people; *Hunter*-based activities require players to find specific people or objects; *Artist*-based activities invite players to create artwork and share it; and *Volunteer*-based activities invite players to contribute towards a better community.

This section explores the validity of these findings for adolescents. This case study explores 1) whether the 7 types of activities distinguished above are also of interest to adolescents, and 2) whether the types of interaction required for the 7 types of activities differ. To address these questions, this section starts by exploring which specific game activities are of interest to adolescents in their own neighbourhood. It reports on a case study where adolescents are exposed to their neighbourhood and co-design content for actual LBGs in the future (as done in this thesis in chapters 6 and 7, and appendix C). This content is then analysed in the dynamics of play ideated by adolescents, to understand if and how these fit with current knowledge on the types of activities LBGs for this purpose should offer (or whether this set of types needs to be expanded/changed). By doing so, this section 1) offers an understanding of what adolescents want to play specifically in their neighbourhood, 2) explores if what adolescents want to play is in line with current knowledge on the types of activities found so far (mostly based on adults), and, ideally, 3) empowers users in the future by inviting them to play their own co-located ideas. This, together with an understanding

This chapter is based on the submitted article: X. Fonseca, S. Lukosch, and F. Brazier, *What Works? A Framework for the Design and Analysis of Activity Types for Location-based Games for Social Interaction in Public Space*, 2020 (Submitted to Special issue on: 'Smart Cities at Play: Playful Approaches to Urban Space, and Problems of Participation', International journal of human-computer interaction, currently in review).

of the nature of interaction promoted during gameplay, can help future researchers design interventions to foster social interaction in public space that is based on what users wish to play.

4.4.1. RESEARCH DESIGN

To explore the above-mentioned questions a dedicated workshop was organised for young adolescents in which they participated in the design of challenges in their neighbourhood as design partners as described in (Slingerland, Lukosch, and Brazier, 2020).

PARTICIPANTS AND LOCATION

Young adolescents (10-11 years of age) in the same overall area (Feijenoord and Tarwewijk, Rotterdam, the Netherlands) as the case study reported in section 4.1, participated in this study. As 5th and 6th form pupils of a primary school in the area (Christelijke Basisschool De Akker), 64 in total (3 classes in total), they participated in this study in the context of their technology curriculum. The group was balanced in terms of gender mix, and, according to their teachers and the school director, representative of the local neighbourhood with respect to ethnicities.

PROCEDURE

Each of the 3 classes of students participated in the workshop over a course of 2 days.

On the first day, two researchers visited the class of students to brief them about the context of the research (on location-based games for social interaction tailored to their neighbourhood), to provide them with examples of activities that could be played, to explain that 3 routes would be walked a week later, and to provide them with a hand-out with exercises with which they could prepare: to find more information on the neighbourhood and its local history (e.g. by asking their parents), and told that their ideas would be implemented in a LBG for them to play at a later date. They were also handed consent forms for both participants and data collection, to be signed by their legal guardians/parents to be returned to school prior to the second day of the workshop (a week later).

On the second day of the workshop the class was split up into smaller groups of 4-6 adolescents each (by the teachers), with at least 2 researchers and one teacher for each. Each group was randomly attributed to one of the 3 predefined routes. These 3 routes (figure 4.7) were on average1.4 kilometres long, around the school (with start and finish points at school), and participants walked their assigned route for a period of up to 1 hour and half. Each group was tasked to propose gaming activities en route to be included in a LBG at a later date. Lastly, on return to school, participants were asked to reflect on their experience, again briefed on what would happen to their ideas (i.e. to be included in an LBG prototype), and reminded that a few months later the researchers would come back for them to test their ideas in a gameplay session (see chapter 7).

The two days per class were held sequentially, and are summarised as follows:

- Day 1
  - Briefing of research context and purpose of workshop with examples
  - Explanation of the homework, and of day 2

  - Attribution of consent forms for participation and data collection

- Day 2
  - Division of class into smaller groups
  - Attribution of teachers and researchers, and random attribution of a route, to each group
  - Attribution of materials to participants (booklets, smartphones, and writing materials)
  - Walk around the neighbourhood on the attributed route
  - Debriefing session on how it went, and on next steps

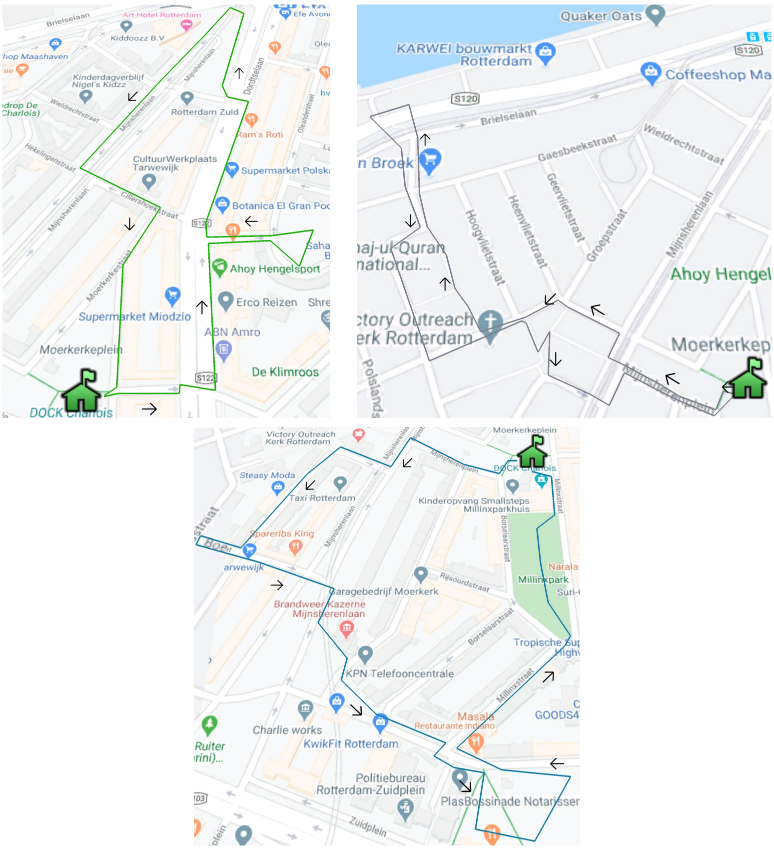


Figure 4.7: 3 Routes used in Tarwewijk and Feijenoord: 1 (top left), 2 (top right), and 3 (bottom).

Method and Data Collection

During the walk of each route, the teacher and researchers were responsible for guaranteeing that the young adolescents would stay en route, participating in, and fostering, debate on what participants found interesting to do and where, and writing observations down on paper. Each participant was assigned an initial role: *Interviewer*, *Photographer*, *Note Taker*, *Recorder*, or *Navigator*. The *Interviewer* role entailed asking questions both to other participants, teachers, researchers, and passers-by. The *Photographer* role entailed taking pictures of points of interest for playing games around the neighbourhood, with a smartphone given by the researchers at the beginning of the walk, and taking pictures of people and discussions en route. The role *Note Taker* involved writing down ideas and thoughts with regard to activities h/she/the group wants to play, and its respective location (if not known, the teacher and/or researchers would help). To this end, writing materials (pen, paper, and a hard clipboard) were handed out at the beginning of the walk. The *Recorder* role recorded interviews, interaction with passers-by and group debates in audio, on a smartphone also handed out at the beginning of the walk. Finally, the *Navigator* role consisted of keeping the group on track, making sure they followed the path associated to the route. To this end, a booklet containing turn-by-turn instructions with pictures of the attributed route was handed out at the beginning of the walk. Participants could change roles throughout the route, to try new tasks and maintain engagement.

Data collected consists thus of observations made by researchers written down on paper, writings of participants, audio recordings, and photos.

Data Processing and Analysis

Data collected was then processed through a 2-step approach that produced one list of specific game ideas desired by the participants to play in their own neighbourhood. As a first step, transcriptions of the audio recordings collected by the adolescents were analysed by 2 Dutch-speaking research staff, whom annotated the ideas of gaming activities proposed. As a second step, the researchers associated the annotated ideas with the writings of the participants, and, when available, with the pictures taken. This step increased understanding of the data produced by participants (which was not always comprehensible, e.g. in writing, or ideas expressed), and to curate the data into a list of gaming ideas. The result was then translated to English by the researchers.

Results

56 game ideas result from the workshop and from the data processing documented above:

#	Description of the game idea
1	More swing seats.
2	More colour challenges. coming up with a colour scheme for the square, the nicest wins.
3	Cleaning up challenge: the person who collects the most litter wins the challenge.
4	Come up with ideas for new street names in the neighbourhood.
5	Increase attractiveness of the location: make a plan to increase the amount of lights at the location.

Table 4.6 (continued)

6	Hang up big bulletin boards and make sure people write or hang stuff on them.
7	How long does the school exist? Ask somebody for the answer.
8	For what is wheat used? Think about it or ask somebody. Come up with 5 products that contain wheat.
9	Try to communicate without talking the same language. Play together.
10	Count the number of languages present.
11	Choose a word and translate it into 5 languages.
12	Make a picture [...] (unreadable).
13	Call names and find the corresponding tile (e.g. Johan Cruiff) [famous local football players of Rotterdam]. Ask people to come up with 3 player names and find their tiles [these are tiles with names that can be found on the floor or walls throughout the city].
14	Which stores are here? Why did they build it and when, and which kind of stores can be found at Zuidplein (e.g. Albert Heijn, Primark, KFC,...)?
15	Understanding how it works or what it is: There is a tube on the ground, what kind of water goes through it?
16	Garage Zuidplein: How many kilos can go into the elevator? (answer is 3000 kg).
17	Name 5 tasks/services that are done in garages? (e.g. APK, maintenance, selling stuff, etc.).
18	Making parkour in Millinx park, run and race on it. How long does it take to finish all the parkours? (23s).
19	Investigating the houses: How high are the apartments? Measure, ask the residents or a construction worker.
20	Race and playing twister challenge: play against each other.
21	Who spots them first? Be the first person to spot a white license plate on a car.
22	Challenge people to go to their work using a specific transportation mean (such as only using the subway).
23	Find, within 1 minute, 10 people that use the metro.
24	Count how many Kilometres there are between one stop and the next stop.
25	Count how long does it take for the metro to pass by: play against somebody, the person who wins receives a metro ticket of the other player.
26	Run with the metro to see if you can beat its speed.
27	Playing "tikkertje" [tag game] or running against each other.
28	Acquire knowledge of the neighbourhood, with questions such as: 1) there are many stores around, find 3; 2) which trees are here? 3) Talk to the elderly, check a biology or history book in the shed of free books.

4

Table 4.6 (continued)

29	Knowledge of the neighbourhood: investigating the buildings, talking to volunteers at the community centre, finding recommendations on the neighbourhood.
30	Collect information about Zuidplein, walk around or find it on Google.
31	Going around [the river] on Maashaven, swimming.
32	How many metros pass by each day?
33	Why are you not allowed to park your car here?
34	What can you do here? What is there to eat?
35	Who can make the most challenges?
36	What can you do here? What are these people doing here? How long does it take somebody to park their car?
37	How many challenges can you make within one minute?
38	What can you buy here?
39	How many schools are there? (talk to people, read the signs).
40	When was the neighbourhood built?
41	Play together without speaking the same language, like Play hide and seek, "tikkertje" [tag game], soccer, etc.
42	Be sporty, be the fastest, climb in a tree challenge.
43	Statue challenge: make statue of people in the neighbourhood.
44	Poetry challenge: write a poem about the neighbourhood.
45	Metro quiz: answer questions about the metro, and give the right answers.
46	Find the tile, and lure people to the tile.
47	Interviewing people about what they do at Zuidplein.
48	Find nice things and make a picture of that.
49	Do the parkours.
50	Which flag hangs here?
51	What are the names of the supermarkets here? What are the statues here?
52	Acquire knowledge on the neighbourhood, with questions such as: 1) how long is this street?
53	What is not allowed here? (dogs) [sticker on the door].
54	Now & Wow. (E.g.: Bread factory Meneba used to be a Shell fuel station. The silo that is now used as a party venue used to be for wheat production).
55	Name as many languages as you can.

Table 4.6 (continued)

56	Play together without speaking the same language: Painting.

Table 4.6: Game Ideas from participants.

4.4.2. DATA ANALYSIS

From the results presented above, data is further analysed with the intention of answering the two research questions this case study addresses: 1) **whether the 7 types of activities distinguished above are also of interest to adolescents**, and 2) **whether the types of interaction required for the 7 types of activities differ**.

PROTOCOL OF ANALYSIS

To address the first question asked by this case study, all game ideas were categorised on the basis of their description as depicted in table 4.7 by one researcher into the 7 types of activities, and this distribution was double checked by a second researcher. The categorisation made it possible to see whether 1) all game ideas could be represented by these definitions (or whether new types of activities were needed), and 2) whether there were types of activities for which no game ideas were proposed (thus representing that that type of activity was not thought of by any participant). With regard to the second question, the analysis aims to provide a theoretical grounding of the types of activities on the forms of social interaction fostered. A researcher analysed the definitions of each type of activity from 4.7 and coded each type against the literature on 1) the nature of the social interaction (focused or unfocused, as defined in section 2.8, and 2) the type of interaction (see figure 4.8 and section 2.8). The coding scheme was also double checked by a second researcher. For convenience the information used for the coding is repeated below:

A. User-centred Types of game activities

Type	Description
Artist	This type of activity requires players to design artwork in and about their neighbourhood, based on creative processes individually or collaboratively. Such artwork might be abstract and personal or collective, and represents a creative expression about the player's neighbourhood. For example, creating a song or musical performance (rapping), writing a poem, or storytelling.
Athlete	This type of activity requires physical activity to be solved. The activity can be solved by either doing a specific challenge requiring physical action (e.g. engaging with at least five people for a given purpose), or by varying the quality of the performance itself (e.g. see who can finish the free-running the fastest).
Detective	This type of activity requires finding information and answering questions about factual knowledge related to the surrounding environment. Players have to search for information in their neighbourhood, such as asking people about local heroes depicted in tiles in the footpaths in their neighbourhood.

Table 4.7 (continued)

Explorer	Players are required to explore their neighbourhood, i.e. by learning and comprehending more about their own neighbourhood and the people who live there. Activities of this type might include discovering the origins of a neighbourhood. It might lead players to an unknown point of interest of the neighbourhood (e.g. an old building, a local initiative) and ask them to engage with random people to discover its origins.
Hunter	The behaviour elicited by this type of activity is linked to finding specific type of people or objects, as opposed to finding random people. Hunter is about finding tangible things that can be human, animal, or an object. For example, finding the person responsible for the community centre to ask what types of activities can be done there. If and when such people cannot be found at a given time, players can find ways to still address the challenge (e.g. finding a QR code attached to the community centre explaining exactly what they would like to ask the person).
Inventor	Inventor type of activity requires players to propose new ideas to address an issue in the neighbourhood. Players in this type of challenge may explore interventions for their neighbourhood, and explore opportunities to increase the livability of their neighbourhood. Examples of this activity are possible interventions to change their neighbourhood, designing a new playground, or a new colour scheme for the location.
Volunteer	Players are invited to contribute towards the community, and are incited to help others or contribute to the quality of life in the neighbourhood. An example of an activity of this type is picking up trash at a specific location to make a nice piece of art with it, and taking a picture of it to publish in the media of the local community, before the trash is collected.

Table 4.7: User-centred types of activities for LBGs for social interaction in public space. See sections 4.1-4.3.

B. Nature of social interaction

Definitions used in this research for focused and unfocused interaction are the ones originally published by Bartis (Bardis, 1979) and Goffman (Goffman, 1955, 1961):

> "**Focused interaction** is interaction in a group of persons that have a common goal. These persons may have been familiar with one another in the past or they may become familiar for the first time during their focused interaction (e.g. a group of students studying together for a final examination)" (Bardis, 1979)
>
> "**Unfocused interaction** includes neither a common goal nor such familiarity even during the process of interaction. In fact, the interacting persons may be unaware of their interaction (e.g. interaction between pedestrians who avoid disastrous collisions by following traffic etiquette and regulation)" (Bardis, 1979)

C. Types of social interaction

The types of social interaction discussed in section 2.8 (and depicted in figure 4.8) are repeated here:

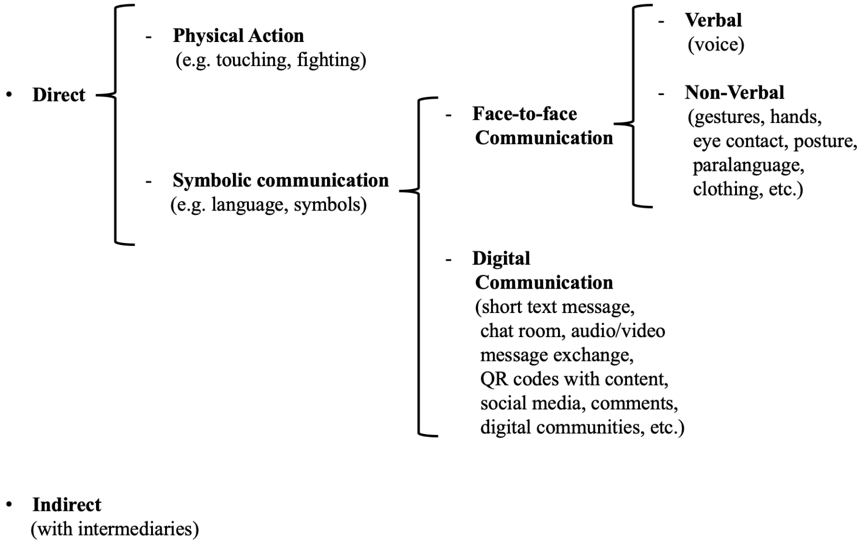


Figure 4.8: Types of social interaction (same as Figure 2.7).

YOUNG ADOLESCENTS WANT THE SAME ACTIVITIES AS ADULTS, THOUGH WITH DISTINCT PREFERENCES

From the game ideas on table 4.6, the attempt to distribute the 56 game ideas into the existent types of activities is shown in table 4.8.

Type	Game Ideas	Total
Artist	2, 12 , 44, 48, 56	5
Athlete	9, 18, 20, 21, 22, 23, 24, 25, 26, 27, 31, 35, 37, 41, 42, 43, 49	17
Detective	7, 16, 19, 32, 39, 40, 45, 51, 52	9
Explorer	4, 8, 10, 11, 14, 15, 17, 28, 29, 30, 33, 34, 36, 38, 47, 54, 55	17
Hunter	13, 46, 50, 53	4
Inventor	1, 5, 6	3
Volunteer	3	1

Table 4.8: Distribution of game ideas into each type of activity.

This attempt was successful at categorising all of the ideas that the participants gave, which means that the existent framework of types of activities also represents what these participants prefer to do in their neighbourhood. Yet, it is possible to see that even though all the types have a corresponding game idea, the ideas cluster more into specific types.

Figure 4.9 shows how the game ideas cluster into each of the types, and reveals that the types *Explorer* and *Athlete* together constitute ≈61% of the preferences of adolescents (≈30% the former, and ≈30% the later). Following these two types is *Detective* (≈16%), *Artist* (≈9%), *Hunter* (≈7%), *Inventor* (≈5%), and *Volunteer* (≈2%). This indicates that these adolescents really have a preference for exploring the neighbourhood and finding more information by engaging with the environment and the people in it, while also playing activities that are physical and fun.

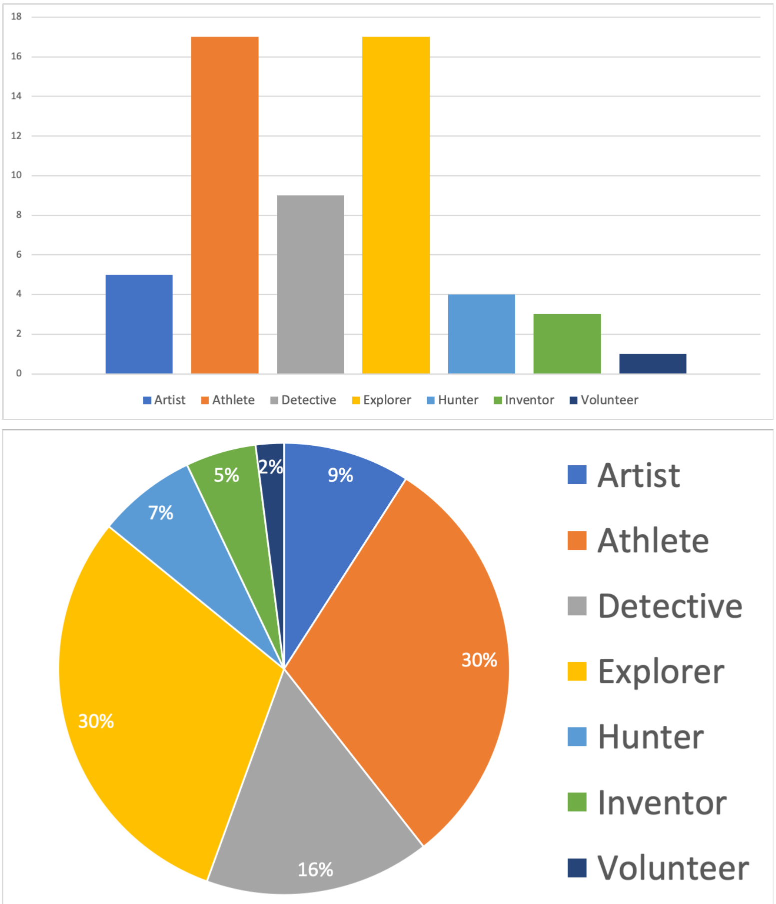


Figure 4.9: Distribution of game ideas per game activity: number of ideas per type (top), and percentages of distribution (down). Same colour scheme used in both graphs.

This research proposes the studied 7 types as a framework of types of activities that users, both adolescents and adults, want to play in their neighbourhood for social interaction. This framework, presented as a framework in figure 4.10, provides a simplified definition for each of the 7 types discussed, and indicates the types of activities existent research with both user groups prefer to play with regard to activities for social interaction in the public space of their neighbourhood.

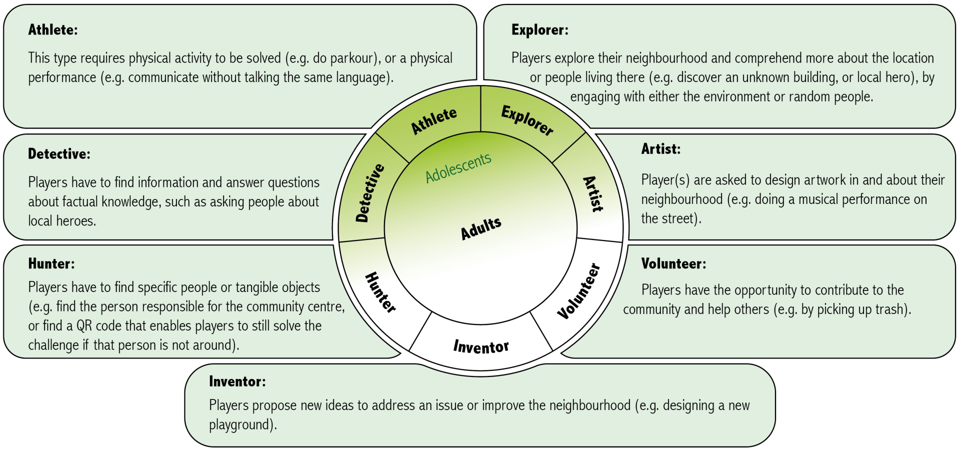


Figure 4.10: User-centred framework of types of activities for social interaction in public space (Fonseca, Lukosch, and Brazier, 2020b).

As previously indicated, all 7 types mentioned in the framework are preferred by both adults and young adolescents (both indicated in the centre of the framework). The framework of figure 4.10 distinguishes (with a green gradient at the centre) the types of activities preferred most by adolescents in particular, in line with the distributions shown in figure 4.9: more than half of the adolescents that participated in this study want to play the *Athlete* and *Explorer* types of activities, while also having a substantial inclination for the *Detective* type to a varying degree. To a lesser extent, the types *Hunter*, *Artist*, *Inventor* and *Volunteer* combined were also mentioned by ≈23% of the participants, which, while showing not being of their highest preference, indicates these types are also appealing to adolescents.

TYPES OF ACTIVITIES AND THEIR ASSOCIATED FORM OF INTERACTION

The analysis sheds light on the forms of interaction required for each of the game ideas. These forms of interaction are documented per type of activity, and summarised graphically in figure 4.11:

Types of activities and the analysed interactions:

- ***Artist***: Ideas fitting this type of activity are for example proposing a colour scheme, creating pictures or poems, and painting together without speaking to one another. These ideas invite players to do activities together with the group, thus having a common purpose (**focused interaction**). Interaction within a group of players can be both **indirect** and **direct**. On the one hand, indirect interaction can happen because indirect means are used by the first interlocutor to communicate (e.g. drawing, poetry), a means that which will likely be converted into meaning by a second unknown interlocutor. On the other hand, direct interaction occurs when players of these activities perform, i.e. during a performance (**physical action**), for e.g. in the activity of painting together, there is direct coordination between painters. Direct interaction also happens via **symbolic communication**, that is materialised in both **verbal** (talking while performing) and **non-verbal** (the way people perform) **communication**, both **face-to-face**.

- ***Athlete***: Ideas fitting this type of activity are those involving physical performance, for example playing together (e.g. hide and seek) without talking the same language, doing an activity (e.g. climbing a tree) and counting how long it takes (e.g. finding the number of people that commute with the metro within 1 minute), and playing twister/tag and sports (e.g. soccer, or parkour). The ideas for activities fitting this type are both focused and unfocused: a number are to occur within a competing group (**focused**), with a common goal (often involving competition); and a number contain goals (e.g. finding under 1 minute 10 people that use the metro) that are fast paced and do not really set a "stage" for the interlocutors to get to know one another or share an overall goal (**unfocused**). All of the ideas within involve **direct** interaction between both a group of players and passers-by in the neighbourhood, and potentially involve **physical actions** (e.g. touching/grabbing) and the use of **verbal** and **non-verbal** communication during **face-to-face** encounters.

- ***Detective***: Ideas mentioned for this type of activity require players to find specific information (e.g. how long does the school exist) and investigate a specific topic (e.g. a given house, a street, or the quantity of schools in the neighbourhood). These activities are all **focused** in nature: the person interacting has to find specific information. The type of interaction is **direct**, and is mostly based on **face-to-face** dialogues (**verbal**) and the way these are conducted (**non-verbal**).

- ***Explorer***: These activities invite players to engage with both the environment and the people in it, thus providing both focused and unfocused interactions. **Focused** interactions occur in the activities where there is a clear goal (e.g. finding what can be done in the community centre, by talking to the people working there). In turn, **unfocused** interactions can also occur with this type, when activities are not so clear in purpose (e.g. collect information about the neighbourhood, or interview people about what they do). With both focused and unfocused, players engage **directly** with both the group (e.g. coming up with ideas for new street names together) and with passers-by (e.g. interview people), which use **face-to-face verbal** and **non-verbal** language.

- ***Hunter***: The ideas fitting this type invite players to find specific objects around the neighbourhood (e.g. tiles, flags, stickers), or ask about specific information to passers-by. The nature of this interaction is **focused**: players have an objective to find specific information or objects, even when talking to strangers. Communication is **symbolic** and can occur in two ways, either **digitally**, or **face-to-face**. Digital communication occurs when players have to find given objects that can contain messages left by another unknown person (e.g. a QR code displaying text or a picture linked to the activity). In turn, face-to-face communication occurs when players engage with passers-by to find information and solve the activity, in situations where both **verbal** and **non-verbal** types of interaction can occur.

- ***Inventor***: Ideas fitting this type aim at solving problems, to for example provide more options to share information (e.g. more bulletin boards) and improve the neighbourhood (e.g. more swing seats, more lights). The nature of the interaction is **focused**, as there is a clear goal (proposing ideas), and it occurs through **indirect** and **direct** means. Similar to the type *Artist*, indirect means are used by the first interlocutor to propose new ideas (e.g. designs, sketches), that are likely to be interpreted by a second interlocutor not known à priori by the first one. Direct communication, on the other hand, happens in activities where players solve/perform an activity together, that can include both **physical action** (e.g. while sharing the same canvas) and **symbolic communication** during **face-to-face** exchanges. The latter can, in turn, be **verbal** (e.g. discussing ideas), or **non-verbal** (e.g. the design itself can contain symbols).

- ***Volunteer***: The ideas fitting this type (cleaning up challenge: the person who collects the most litter wins) promotes a **focused** and **unfocused** exchange: focused, because there is a goal among players competing; and unfocused, because the act of cleaning the neighbourhood can set up dialogues with passers-by that are random (e.g. someone asking what players are doing and why). These exchanges also may require indirect and direct communication. On the one hand, **indirect** communication happens when a player contributes to the community including people in that community: cleaning the neighbourhood (in this example) sends an indirect message to other members of the community saying that that specific person cares about the neighbourhood, which in turn can have a cascading effect. On the other hand, **direct** communication happens between 1) a group of players competing to win an activity, and 2) passers-by. A group of people whom perform this activity together can physically interact with one another while performing (**physical action**). At the same time, this type of activity also promotes **face-to-face** dialogues both between players and strangers, whom use **verbal** and **non-verbal** cues to communicate.

Figure 4.11: Framework of activity types and the forms of interaction theoretically fostered.

4.4.3. Discussion and Limitations

This research starts from the previous knowledge on types of activities that users wish to do in location-based games developed to foster social interaction in their own neighbourhood. This knowledge, initially based on workshops with adults, consists of 7 types of activities. This research strengths these findings by focusing on adolescents and what they desire, and develops a case study to answer two questions: 1) **whether the 7 types of activities distinguished above are also of interest to adolescents**, and 2) **whether the types of interaction required for the 7 types of activities differ**.

The first research question can be answered affirmatively: the 7 types of activities previously identified were also proposed by young adolescents. The analysis further explores the preferences of adolescents: the types *Athlete*, *Explorer* and *Detective* top the list, while, to a lesser extent the types *Hunter*, *Artist*, *Inventor* and *Volunteer* are still appealing to play.

With regard to the second research question, this research argues towards the forms of interaction that each type is expected to promote. Lessons learned from the literature-based analysis are that each type of activity promotes a gameplay with a clear (focused) or unclear (unfocused) goal for the interaction. Beyond its nature, interaction can occur in a direct or indirect way, depending on whether indirect means of expression or communication are used. In the cases where interaction occurs in close encounters (directly between interlocutors), it is further categorised into several types: involving physical interaction (physical action), symbols (e.g. language, signs), and other forms of communication present in face-to-face exchanges (verbal, and non-verbal) or digital ones (e.g. asynchronous messages).

This research shows that the types *Inventor*, *Hunter*, *Detective*, and *Artist* offer activities that are clearer in purpose and guide social interaction both within a group of players and passers-by, whereas activities of the type *Athlete*, *Explorer*, and *Volunteer* involve less purposeful engagement with people on the street. The types *Artist* and *Inventor* include examples of activities where players are invited to draw, sketch, write a poem, or express an idea for improvement of the environment in which they live. The activities of type *Volunteer* also promote indirect interaction, but in such cases the interaction is indirectly communicated through giving an example of behaviour. In direct interactions: the types *Inventor*, *Volunteer*, *Artist*, *Athlete* invite players to do activities with physical exchanges (e.g. touching, grabbing); the type *Hunter* is the only type that includes examples of activities involving explicit digital communication; and all types of activities with face-to-face interaction, afford both verbal and non-verbal exchanges.

As such, this research strengthens our earlier findings on what users want to play in games of this type (Fonseca et al., 2018a; Fonseca, Lukosch, Lukosch, and Brazier, 2020; Fonseca et al., 2017; Slingerland, Fonseca, et al., 2020), and more strongly clarifies the preferences that adolescents have for activities fostering social interaction. It also advances current knowledge on the forms of interaction that each type of activity is likely to promote, thus providing a bridge between the gameplay offered by each type of activity and the form of interaction it can promote in public space.

Limitations

This case study explores 2 research questions with young adolescents in the areas of Tarwewijk and Feijenoord in Rotterdam. The first limitation of this study is that the findings are based on the preferences of these participants, and further research is required to generalise these both with regard to different locations and other participants of the same target group. A second limitation of this study is in the association made between the types of activities users want to play and the form of interactions they trigger. The analysis offered in this case study is based on literature alone, and the strength of the findings can be enhanced with case studies designed to practically experiment and observe the triggered interactions, and correlate those with the types of activities. Lastly, this study sought to validate the existing list of types of activities (Slingerland, Fonseca, et al., 2020), and the findings of this case study are in line with previous research done. It is, however, possible that future research reveals more types of activities, or that the preferences of users change for example in function of time (different generations) or place (different countries). Nonetheless, the findings of this case study, even though applicable to the participants studied, are not weakened by these limitations.

4.5. OVERALL DISCUSSION

This chapter focuses on increasing understanding of what users require of location-based games for meaningful gameplay experience for games designed to invite social interaction in the public places surrounding them. A series of 4 case studies explore the preferences, needs and desires of users for meaningful and engaging social exchanges. Lessons learned cover 1) user requirements at the level of gameplay, 2) user requirements for the content that such LBGs should offer (types of activities), 3) knowledge on the ways adolescents and adults prefer to interact with other people and to be exposed to the neighbourhood, and 4) a clearer understanding of the relationship between the activities users want to play and the forms of interaction they potentially trigger.

Different social settings (Rotterdam - with socially challenging neighbourhoods, and The Hague - for neighbourhood engagement) reveal that, as expected, users differ in their preference for types of activities to be performed in a game. Yet, a common ground on the types of activities is found across the studied locations and users: they want to be Artists, Volunteers, Inventors, Hunters, Detectives, Athletes, and Explorers. Young adolescents have a strong preference for the last 3 types of activities.

4

This chapter also shows that involving users as informants and co-designers of activities for games: 1) provides "food for thought" for game/activity design, and 2) enables a better comprehension on the ways users prefer to interact with other people and their environment. With respect to the latter point, adolescents showed to prefer activities that 1) involve physical exertion and contact with friends, and that 2) explore the world surrounding them and engage with face-to-face conversations with people living in their neighbourhood. In turn, adults enjoy activities where they 1) discover the neighbourhood (also through digital means such as QR codes, as long as the technology used is familiar to them), 2) see there is a purpose (e.g. sharing meaningful information about the neighbourhood with others) and that use historic land marks, and 3) have opportunities for natural conversations and face-to-face collaboration with other people. An interesting finding is the desire users have for a balance between known and unknown locations. Users reported that, on the one side, they enjoy the prospect of exploring new neighbourhoods, but that, on the other side, they also require a bit of familiarity. The specific game ideas can be reused by practitioners of game design when preparing future games targeting the same neighbourhoods studied, and/or serve as inspiration for similar game activities for LBGs for social interaction in public space.

As such, a location-based game for social interaction in public space, to provide meaningful and engaging opportunities for players to interact, needs to take these lessons learned into account and consider them as requirements.

5

Key Architectural Components for Location-based Games for Social Interaction

The solution often turns out more beautiful than the puzzle.

Richard Dawkins

Previous chapter explored the many sorts of requirements users have, by involving them in an iterative requirements design approach with multiple techniques to probe them. This approach involved adolescents and adults as informants on their preferences, needs and desires for gaming activities in their neighbourhoods, and studied, through different methods and tools, how these change across different users and locations. It advances design guidelines for gameplay requirements, discovers 7 types of activities that LBGs for social interaction in public place should offer to these users, and reveals specific gaming activities they want to play.

However, before these lessons learned can be put into a game design and be tested in a real LBG prototype, this research explores how LBGs are put together from the technical perspective. This is important because LBGs offer unique gaming experiences, through unique functionalities, when compared to traditional games (Couch, 2017; Oppermann and Slussareff, 2016). Some examples of such distinctive features are the adaptation of a game concept to an environment's space using digital overlays with context-based information,

This chapter is based on the submitted article: X. Fonseca, S. Lukosch, and F. Brazier, *Modular Software Architecture for Location-based Games Designed for Social Interaction in Public Space*, 2020 (Submitted to Entertainment Computing Journal, currently in review).

with interaction required with the environment and other people to advance the game, and potential support for different levels of exertion (Fonseca et al., 2021; Mullen, 2013; Oppermann and Slussareff, 2016). Such games have been shown to be capable of triggering engagement from players worldwide in playful ways (Paelke et al., 2008), and yet, designers and developers of games have no guidance on how to create such games from the perspective of system design. On the one hand, different components and names are used in the literature to describe similar functionality, which in turn leaves room for interpretation on the precise functionality provided. On the other hand, completely different components are proposed by designers and developers as key, causing lack of consensus on what is actually needed in an LBG at large. In addition, designers and developers discuss key functionality that are not key to the game architecture itself (Avouris and Yiannoutsou, 2012; Naliuka et al., 2010), but to its application.

This chapter seeks to gather current understanding on what system components are needed to sustain social interaction in public space, so that such key information is taken into account when proposing a game design that embodies the users' requirements in a way that works. To do that, this chapter analyses a number of existing LBGs that players love(d) to play, and looks into which components are key for such games to work, and what is common across them.

5.1. Research Methodology

This chapter focuses on LBGs, i.e. games that use locative features of smartphones, and that potentially trigger social interaction (direct or indirect, offline or digitally) in outdoor space. It starts off by selecting the games to be analysed (in the following chapter). The selection procedure started with an online search for lists of the best LBGs, containing reviews and public opinions of what players love(d) to play. The online search was conducted using DuckDuckGo© and Google© search engines, both with the query "best location-based games" . Five websites with lists of games[1,2,3,4,5] with LBGs up to the period of 2018 were chosen. The following criteria were used to select a limited number of games from these lists: games displaying 1) strong potential for social interaction, 2) with millions of players, and 3) mentioned multiple times across these websites. The rationale for these criteria is that location-based games fostering interaction, particularly face-to-face, are the focus of this research. Games that are capable of bringing players physically together, either because they want to play together/against one another or because they need other people to explore new modes of play, bear a potential for games with more serious purposes. Games that contain millions of players, and are mentioned multiple times across the internet, show their success, and can highlight features that worked for them and might prove to be essential for

[1] https://www.quertime.com/article/20-extremely-addicting-gps-location-based-mobile-games/, 20 extremely addicting GPS location-based mobile games, July 2018, last visited on December 23, 2020.

[2] https://www.pockettactics.com/guides/location-based-games-ios-android/, The best location-based & GPS games on mobile, Jan. 2020, last visited on December 23, 2020.

[3] https://www.redbytes.in/gps-mobile-game-development-ios-android-2018/, Best GPS location-based games on iOS and Android 2018, Oct. 2017, last visited on December 23, 2020.

[4] https://www.digitaltrends.com/gaming/best-location-based-gps-games/, 5 great location-based games that aren't 'Pokemon Go', Jul. 2016, last visited on December 23, 2020.

[5] https://beebom.com/best-location-based-gps-games/, 8 Best location based GPS games you can play, Jul. 2017, last visited on December 23, 2020.

the desired type of game play.

With regard to data analysis, the selected games were analysed with the focus of understanding their key functional components. The analysis focuses on 1) their goals, 2) prominent features, and, when possible, 3) choices at the software/system architecture level that are clearly needed to support the game. The next step consisted of cross checking the identified components across all analysed games, to identify commonalities in high-level functionality, as high-level features. These high-level features are then used to propose key components for a software architecture with a modular structure that allows developers to choose different ways of implementation.

5.2. ANALYSIS OF LOCATION-BASED GAMES TRIGGERING SOCIAL INTERACTION

Based on the first criterion from sub-chapter 5.1 (heavy social interaction, preferably offline), *Geocaching*, *Recoil*, *Pokemon Go*, *Ingress* and *Orna* are selected due to their strong capacity to instigate dynamics of play with multiple people offline. *Geocaching* and *Orna* bring people together to form teams; *Pokemon Go* and *Ingress* offer events worldwide where people compete in-situ; and *Recoil* is a multiplayer-based game where people have to come physically together to play. Regarding the second criterion (millions of players), *Pokemon Go* and *Parallel Kingdom* are selected, as the former reported 45 million players worldwide[6], and the latter 2 millions[7]. Other potential choices could be *Ingress* and *Landlord*, both with little over 400 thousand players each, but no other game comes close to these numbers of players. Lastly, *CodeRunner*, *Ingress*, *Pokemon Go*, and *Geocaching* are selected because they are mentioned multiple times across the selected websites (at least 3 out of 5 times).

Based on the selection of all the criteria, 7 games were selected for the analysis: *CodeRunner*, *Geocaching*, *Ingress*, *Orna*, *Parallel Kingdom*, *Pokemon GO*, and *Recoil*. Other criteria and other games could be selected for this game analysis, yet, the purpose is to understand what are the essential building blocks for such games to be successful from the design and software/system's perspective. This can be done, not by analysing an exhaustive list of games, but by selecting games that are different and vary from one another, and that were/are substantially played and enjoyed by large communities of players. The criteria used reflects this. The analysis done was based on play testing and consultation of online reviews whenever possible.

5.2.1. CODERUNNER (DATE: 2012)

CodeRunner immerses players in spying and conspiracy through audio storytelling that is complemented by augmented reality. The game pays substantial emphasis on the fictitious storytelling: players are recruited as agents for governmental department, and they need to hack objects such as tower antennas or electrical boxes, eavesdrop other people's communications, hack and disable power grids, take pictures of real world objects, and pass as 'the good guys'. There is a strong dynamic of pressure set by the game, based on the secrecy of

[6] https://www.businessofapps.com/data/pokemon-go-statistics/, Pokemon Go revenue and usage statistics (2019), May 2019, last visited on December 23, 2020.

[7] https://www.pocketgamer.com/games/004719/parallel-kingdom/, Parallel Kingdom, last visited on December 23, 2020.

the activities involved, and the dynamic of not being caught doing fictitious illicit activities. Regarding social interaction, players act as agents that interact with the evidence left behind in the real world by other agents. Players can interact with other players by chance in real life and get to know part of their play, but most of the interaction appears to be promoted in the 'shadow' of the player.

Some of the main features of the game are based on players walking in the real environment with a 2D map overlaid with information. Audio transmissions tell players how to navigate the real world and proceed, and the game offers a feature which is the advancement of the storytelling that is bound to the context of the player (e.g. a target inside a bus in the story, to the closest bus stop to the player), which aims at blending the storytelling of the game and the real world.

Interactions between game and player, the environment, and players, are central to the game. The game interacts with the player through audio, which aims at immersing the player into the narrative. Players have to interact with the digital map (touch and swipe), to navigate their surroundings and create drop points for other players to interact with. The game is also strongly based on interacting with the real environment and leaving objects behind, which is also a mechanism of interaction between players.

Task completion is a big feature of the game, based on stealing private data and uploading it. Tasks mandate breaking and entering into locations through solving puzzles found in game objects. Players go to specific locations ('drop points'), hack them to steal evidence, and move on to the next challenge. This is heavily dependent on player participation: the mini challenges offered by the game are created by players. They leave real objects behind that contain private data, and signal those locations on the map. Other players have to find these and solve the puzzles to open them.

Player participation is a regulated by a community effort, that enforces best practices of play: players can flag poor contributions of other players to be removed from the game. This reveals a top-down management of players and their contributions.

5.2.2. Geocaching (Date: 2000)

This is a digital treasure hunt game where players hunt 'caches' of different types (physical or digital), sizes, difficulties, characteristics, and containing a ledger and trading object(s). Players have the purpose to find these caches in secrecy, log their visit, and optionally exchange objects by leaving them behind. Distinct game plays are triggered with different types of caches: 1) caches with one exact location, 2) multiple dependent stages and locations, 3) which require players to find information in the surroundings to solve a puzzle, 4) with IoT devices, 5) moving caches, and 6) digital caches solvable by sending an email with the solution to the owner. Social interaction is triggered through a sizeable community online where players can befriend others, and get together offline to play together.

Key to the game are elements that position players and help them advance: a map, a list of caches with their distances and directions, and a compass. The map has several icons representing the caches overlaid on it, and each icon represents a type of cache. Players navigate by using the compass to locate a cache, or by searching the environment for information on the final coordinates, to mark it as solved. The main interaction made by players is with the physical caches in the environment, which involves writing on them and trading objects. Regarding the interaction with the digital game, players select caches via the game interface (touch), and use it to introduce the answers and mark them as solved, or find digital caches instead.

Another important feature for the prolonged life span of this game is statistics. The game is played without a strong digital component, but the evolution of the game play throughout time is marked by the comparison that players can make across themselves. It is based on 1) the quantity of caches solved and their different types, and 2) how many of these were firstly solved by each player, which establishes competition and collaboration between themselves.

Geocaching revolves around a strong community of players, which is responsible for the sustainability of the game and the maintenance of its secrecy and other desired behaviour during play. Players may be compelled to hold onto paid tradeable objects, place caches in dangerous places, or flag caches that require maintenance, and it is up to the community to flag ill behaviour and less than ideal situations.

From the system's perspective, this game requires smartphones and other mobile devices to be played, and offers an online platform for several functionalities linked both to the game play and the report of disagreements between players, which the company can act upon. This highlights the features of central orchestration and administration of content and players.

5.2.3. INGRESS (DATE: 2013)

A 'capture the flag' based game where players search, acquire, and link digital 'portals' together. Portals are located in real-world points of interest (POIs), and players have to capture them for their faction. Storytelling centres around the leakage of matter in this world, and what each faction believes should be done with it. Portals belong to one of the two factions, or are unclaimed. The game offers events around the world for players to physically gather together and battle in tournaments.

The game amplifies the player's understanding of the surroundings, supports navigation, and offers interaction with the digital portals. A map highlights portals with different colours, and shows which are linked together based on the dominance of the factions in the area. This also informs the player on where to walk: if the player can contribute to conquer a prominent portal and connect different, unconnected areas owned by the same faction, the dominance of this faction will be improved (figure 5.1).

Figure 5.1: Dominance of the resistance faction in Ingress, based on connected portals[8].

The game play is based on touching on the digital map, portals, and game items required to destroy and conquer portals. Players interact with these, and a mechanism of interaction based on audio feedback informs players on the current situation of the game.

The game presents key features that fuel collaboration and competition between players. Higher player level secures stronger items and portals, and bigger regions of connected portals means stronger factions in the region (figure 5.1, blue area). It is also shown how far players are in the game through a leader board with the factions, showing who is winning and the best 50 players per faction.

The game reveals some coordination and administration done by the company both at the content and functionality levels. Events[9] are organised world-wide for thousands of players to come together and fight in tournaments, talk to one another and get together to conquer portals, which means that the company set up and manages the architecture of the game in such a way to scale up and support a substantial load of players, both during events and across the world.

A recent functionality rolled out by the game is the participation of the community in content creation[10]. It enables players to participate by suggesting new locations for portals online that can be used in Ingress and other products of the company. Players have to have a minimum level to be able to propose suggestions, and they can review the suggestions of other players under safety guidelines[11]. The company then chooses what to do with the content, which reveals administration of content and players.

5

5.2.4. Orna (Date: 2018)

Orna is a role-playing game in which players turn their real world into a land of monsters, explore it and defeat monsters and bosses in turn-based battles, collect items and learn spells to be used in battle, and conquer real-world points of interest around the world. Players have to level up, create or join kingdoms, and unlock functionalities that allow them to engage with other players (to fight alongside or against them).

Orna presents players with a 2D map representing their positioning in the real world, which augments players' notion of what exists around them and enables further engagement with the game. Icons overlaid on the map allow them to engage with monsters, shops and dungeons around them, which are key for players to advance (e.g. blacksmith, to upgrade the player's armour). These are put in specific real world locations, which makes players on the lookout for kingdoms and key icons around the environment.

The game indicates where players have to go to complete game quests, and these end up leading players to different locations on the map. Figure 5.2 (left) shows these indications: an icon acting as compass, a text with a cue (e.g. a mysterious local fountain), and the distance in meters. Icons closer to the player can be immediately interacted with.

[8] http://www.anarchogeekreview.com/video-games/ingress, The Anarcho-geek review, Aug. 2015, last visited on December 23, 2020.

[9] https://www.ingress.com/events, Ingress Prime Upcoming Events, last visited on December 23, 2020.

[10] https://nianticlabs.com/blog/poi-devinsights/, Developer Insights: Engaging Player Participation in our new PokeStop Nomination Program, Sep. 2018, last visited on December 23, 2020.

[11] https://wayfarer.nianticlabs.com/, Niantic© Wayfarer!, last visited on December 23, 2020.

[12] https://cdn.mobilesyrup.com/wp-content/uploads/2019/11/orna-screens2.jpg, Orna is the GPS RPG Pokemon Go never was, last visited on December 23, 2020.

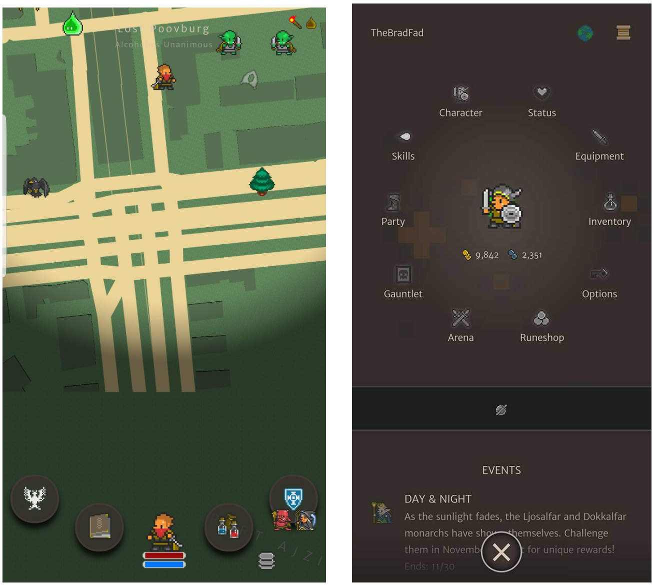


Figure 5.2: Navigation based on objectives (left), and Events offered by the game (right)[12].

The game offers two types of interactions: between the player and game, and between players. Regarding the former, it can be seen best in turn-based battles, where players use a menu during battles to for e.g. attack or flee. The latter is also based on the same menu-based mechanisms that are activated only from a certain level onwards: players can digitally fight between themselves, or create parties of players (when in close physical proximity) to raid bosses and battle together.

The game revolves around the development of the player's character to unlock new parts of the game. Defeating monsters in battle renders players some experience points and key items to level up and unlock new modes of play and content, such as the conquering of new territory. Kingdoms are formed once players claim new points of interest in the real world, join existent kingdoms, or create their own.

Orna players can contribute to the game media with assets, art, or audio[13]. This content is then potentially curated by the game company, used as is, discarded, or reused in future games of the company. This means that the game is co-created with players, even though the real player's contribution can be changed. This also reveals orchestration done by the company, as it decides on what goes into the game content or not from the pool of contributions of players. Still on the orchestration of the game, the company creates seasonal bosses on a monthly basis (figure 5.2, right), and is responsible for community building and providing support (e.g. reddit and discord).

[13]https://playorna.com/contribute/, Leave your Legacy, last visited on December 23, 2020.

5.2.5. Parallel Kingdom (Date: 2009-2016)

Parallel Kingdom was a game that would turn the real world into a parallel medieval one. Players had to follow prophecies, find scrolls, fight monsters, and claim territories. Players could discover new locations in the game world by physically walking while using a map of the surroundings. Players would explore the digital world for unclaimed territories and resources, and fight monsters and place flags to claim them. They could teleport to known locations, harvest fruits in trees to enhance their characters, and be invited to a strategic play, where they would have to select which equipment is most appropriate to defeat a given opponent. Players could tap on monsters to find information about them, which would help them prepare with the most effective items against those opponents.

Central to the game is the positioning of players in the real world and the navigation required to advance the game play. A digital map with colours are used to overlay the territories that are controlled by other players. These, together with icons representing resources and monsters, augment players understanding on the overall game situation, and on what is possible to do in the game. The icons, together with the topology of the territories, makes players navigate throughout the game.

Key to the game is its genre: real time strategy and role playing, which sets a particular dynamic of play. Based on tapping, players are offered an interaction with the game that is context dependent: icons on the map reveal actions specific to them, and the menus of the game are used to command actions based on the location and the items closest to the player. Functionalities that set player-to-player interaction add to this interaction: players can engage in player-to-player trading, interact directly through messages, forge alliances, and fight together by meeting in person, which promotes offline interaction.

The game is centred on evolution, making players level up by gathering resources, trading them for food, and maintaining a full health bar. Resources can be sacked from enemies, or farmed and harvested, which can be strategically put on the map. The game offered over 20 leader boards that would reward players on a weekly basis and set a competitive game progression for the higher ranks and higher number of resources and land, making statistics and rewards key features in the game.

The game had centralized orchestration, visible in control exerted in public APIs (Application Program Interfaces) offered by the game, and in the initiatives for community engagement done by the company. APIs were made available[14] for players to access a complete list of trades of the previous day, and players were subjected to rules to access them. This orchestration is also seen in the weekly community events and updates[6] constantly offered to players, that helped to maintain the game and its community of 2 million players during its lifespan.

5.2.6. Pokemon Go (Date: 2016)

Pokemon GO requires players to collect all virtual types of monsters spread across the world, and use them to train and win battles in arenas. The game positions players in the real world, where players can visualise 'Pokemons' with and without augmented reality, lure and capture them, and evolve them in real-world POIs. The game promotes quests for players to complete for mythical monsters, and offers a teamwork experience where players can be

[14] https://rapidapi.com/blog/directory/parallel-kingdom-trade-data/, Parallel Kingdom Trade Data API, last visited on December 23, 2020.

part of teams to occupy and defend gymnasiums, raid battles, and defeat powerful Pokemons together.

The game focuses on augmenting the environment of players, and in directing/orienting them to interact with monsters and objects around them. A 3D map is used to reveal the location of battles the player can fight with other players, monsters that have a type dependent to the context of the player (e.g. water type Pokemons at a lake), and this is used by players to search for specific Pokemons only found in specific geographies around the world. A 3D character is also shown on the map, and that is used to show where the real player is faced and assist him/her in the game play. On top of the 3D map and character, the way players navigate in the real world affects how fast they progress in the game (moving faster does not contribute to hatching Pokemon eggs), which influences how to navigate best in the world. The functionalities related to augmentation and direction/orientation highlight the way players interact with the game. Players interact by tapping, swiping and pinching, which are used across the game to manipulate the map view or engage with the game content.

A set of key functionalities the game offers is related to the evolution of players in the game. In-game items are essential, and player level as well. When players attempt to catch a monster, their success depends on the previous catch rate, and type of items used. Players have a maximum level of 40 (linked to the ability of catching stronger monsters), and can be reached by gathering experience points throughout the game. Features are progressively unlocked through experience points, and the quest system also makes players advance.

Central orchestration is also key to the game: 1) events organised by the company rotate around multiple localizations each month, 2) legendary monsters are released during a limited time frame and specific real-world regions, 3) the game was released in a phased manner across the world to support the load of players in the system, 4) content differentiation, as different Pokemons live in different parts of the world, 5) the game needs to handle concurrent access to multiplayer battles, and 6) the company assesses players' contributions on content. Similar to Ingress, players co-create content at level 40 by proposing POIs based on pictures of a location and an explanation of why they believe it should be included.

5.2.7. Recoil (Date: 2017)

This game turns public space into immersive first-person shooter battle fields. It is a multiplayer game where up to 16 players use physical objects to set the stage (e.g. covers such as couches or garages), fight with laser guns, and deploy a WIFI hub to set up a game zone stretching over 70 meters. The game provides players with objectives, offers locations where ammunition can be collected, and tracks every player's movement. Players can order air strikes in the game, complete augmented-reality-based missions, communicate with friends and foes at the same time, and set the objectives of the game play (e.g. search and destroy, or team death match), which allows for multiple strategies and game play.

The game positions players in a real scenario, and offers an engaging way for players to interact. Laser tag guns with physical buttons, illuminated tips, haptic feedback and 3D audio positioning augments players' awareness of grenade drops, air strikes, crossfire, and the location of other players in real-time. The mobile application not only augments the game play, but also helps players navigate the environment: a screen with a map is used to track player's movement, overlay points of interest, and provide arrows and a compass for players to move to drop-offs or go back to the re-spawning site.

The game consists of setting up teams to kill one another, through divide-and-conquer. This progressive competition is key to the game, as it sets a winning team by the end of a set of matches. During each match, players have to collect ammunition and health packs distributed around the playing field, which invites players towards a divide and conquer strategy: players kill one another one by one, recover their condition from the previous combat, and move onto the next target. Different playing modes make players kill 10 players instead of a time-based play, which also promotes the progressive step-based play.

The structure of the game is unique: the smartphone connects dedicated hardware (e.g. guns) with the central infrastructure (hub), which, in turn, connects players and synchronises the game. In terms of game content, it is clear that players administrate the game play, though content is not produced by them. The company adds content and new features to the game by putting new versions of the game in the mobile application stores, and then it is up to players to manage each game session as they see fit. This ad-hoc administration is central to the game, which does not use mobile data plans to connect players to the internet.

The creators of the game made the choice of releasing the source codes of the firmware deployed in the hardware, so that the community could play the game with different, custom-made hardware. Players have the possibility to reuse standard off-the-self hardware and use such firmware to reuse that hardware and customise its behaviour. Nonetheless, it invites no further participation from players, and since 2018 that such code is not maintained.

5.2.8. SUMMARY

Specific Features	Commonalities (1-7)	CodeRunner	Geocaching	Ingress	Orna	Parallel Kingdom	Pokémon Go	Recoil
Map (e.g. 2D, 3D)	7	✓	✓	✓	✓	✓	✓	✓
Game info on the map (e.g. icons)	7	✓	✓	✓	✓	✓	✓	✓
Info aligned with surroundings (e.g. portals at POI)	6	✓	✓	✓	✓	✓	✓	
Location usage to advance game play (e.g. GPS)	7	✓	✓	✓	✓	✓	✓	✓
Augmented Reality	2						✓	✓
Visual indications on where to go/navigate/orient (e.g. arrows)	5	✓	✓	✓	✓			✓
Touch, swipe, or hand manipulation (e.g. zoom out of a map)	7	✓	✓	✓	✓	✓	✓	✓
Players come together offline for interaction and joint game play	6		✓	✓	✓	✓	✓	✓
Interaction with real-world objects	2	✓	✓					
Special forms of navigation (e.g. slower the better, or tele transport)	2					✓	✓	
Game statistics, leader boards, resources, character level	6		✓	✓	✓	✓	✓	✓
Task completion, missions, puzzle solving	7	✓	✓	✓	✓	✓	✓	✓
Unlock new features, access to unique items, different modes of play	5		✓	✓	✓		✓	✓
Player contribution with new content, POI, challenges, or software	5	✓		✓	✓		✓	✓
Maintenance/enforcement of game play, game community, and values	2	✓	✓					
Peer review of players' contributions and conduct	3	✓	✓	✓				
Creation, management, and review of game content or players' contribution, made by the company	6	✓	✓		✓	✓	✓	✓
Centralized orchestration of game (e.g. events, community support, structure, API control, players, or target specific content)	5		✓	✓	✓	✓	✓	
Players administer game play	1							✓

Table 5.1: Summary of the game analysis. Grey boxes are features not common or apparently included; green check mark for games that include the feature; vertical blue bars for the number of games sharing the feature.

Table 5.1 depicts the key functionalities identified during game analysis, and shows if, and how often, these functionalities are implemented in the 7 games analysed.

5.3. KEY COMPONENTS FOR A SOFTWARE ARCHITECTURE

The above game analysis led to the identification of 6 distinct structural components: *Augmentation*, *Navigation*, *Interaction*, *State Progression*, *Participation*, and *Administration*. These are argued to be essential for any location-based game designed to foster social interaction in public space:

Augmentation: All of the analysed games provide players with some form of positioning in the real world, and of relating that position with the surroundings of players. In *CodeRunner*, players have an audio recording instructing them to move to new locations, and the game uses locations such as bus stops and other POIs to show players where they should go on the map. *Geocaching* shows a list of caches on the map, Ingress presents a map with coloured territories and portals to conquer or destroy, *Orna* shows icons of caves and animals on the map, *Parallel Kingdom* showed coloured territories of players and several icons on the map, *Pokemon Go* shows a map with 3D Pokemons around the player's location, and Recoil shows a mini 2D map with the location of other players. These games provide players with a map, and overlay information of the game on that map, whether in form of icons, arrows, or colours. This positioning, and matching of the overlaid information with the real surroundings of players, expand players' awareness of what "exists" around them in the digital game world, and what is possible to do within the game.

Navigation: All games reveal some form of visual orientation of players towards the main goals of the game, and players have to pay attention to these game mechanics in order to even play the game. *CodeRunner* shows drop-off points on the map that tells players where they need to go, and these reveal textual hints on what to do once they get there. *Geocaching* provides players with a compass, that appears once players select a cache from either a list of caches or an icon put on the map. *Ingress* shows portals and territories on the map, and these colours guide players in selecting a direction to destroy or conquer portals. The game negates players the access to these portals unless they are within close range. In *Orna*, players find clues of hidden icons on the map, and arrows with these clues and respective distance from the player are constantly shown and updated. *Parallel Kingdom* allows players to teleport to locations already known to them. The icons shown on the map also guide players on where they need to go. *Pokemon Go* shows the 3D character of the player in the centre of the main screen, and it is oriented by the magnetic compass of the smartphone. Similarly, icons dynamically put on the map influence the navigation of players, and the speed of this navigation influences the completion of game goals (e.g. hatching an egg). Lastly, *Recoil* uses arrows that point to enemies or POI surrounding them (e.g. ammunition), together with a text containing the remaining distance to such locations. Navigation is therefore a recurrent feature in all of these location-based games, with game mechanics that enable players to walk towards specific locations to advance in the game.

Interaction: The analysed games support different forms of interaction to play. Among the most common ways to play these games are: tapping on the screen to interact with menus, engaging with icons on a map (done by all the analysed games), and manipulating the view of a map to get a better perspective (*Pokemon Go*, and *Ingress*). A few games go much further and include interaction with physical objects in the real environment of the player (*CodeRunner*, and *Geocaching*), and dedicated hardware with haptic feedback (*Recoil*), while also maintaining the touch-based methods of interaction. Offline social interaction is also recognised in most games (*Geocaching*, *Ingress*, *Orna*, *Parallel Kingdom*, *Pokemon Go*, and *Recoil*), as their gameplay incites players to meet offline to have fun playing together or to advance the gameplay. All of these features boil down to the way players interact, not only with the game, but also with other players.

State Progression: The analysed location-based games have a clear component of "game", e.g. 1) game elements and mechanics that incite dynamics of collaboration and competition between players, and 2) task completion for rewards. All of the games have task completion, missions and side objectives. *CodeRunner* and *Geocaching* present players with the need to solve puzzles and riddles left by other players. *Orna*, *Parallel Kingdom*, and *Recoil* have missions that make players collect resources and progress in the game. *Geocaching*, *Ingress*, *Parallel Kingdom*, and *Pokemon Go* provide a player with a level, and players can only unlock new parts of the game, and acquire access to new and more powerful items, once they achieve certain levels. Game statistics (e.g. quantity of caches solved), leader boards, and resources collected, are also included in *Geocaching*, *Ingress*, *Orna*, *Parallel Kingdom*, and *Pokemon Go*. These game elements and mechanics indicate the state of progression of players within the game, instigating players to keep playing the game, and are, in one way or another, present in the games analysed.

Participation: With the exception of *Parallel Kingdom*, all games reveal some form of player participation. This participation takes various forms, and is usually facilitated by an online authoring tool (submission system). *Orna* offers the possibility of contributing with new game media. In *CodeRunner* and *Geocaching*, players create physical containers and hide them in public places for other players to find them. Both *Ingress* and *Pokemon Go* have an online system in which players can suggest new POI and reason why. In other games, the participation of players is observed in (un)official online communities, where questions can be asked, improvements proposed, moral values for the game play discussed, and players reported (*CodeRunner*, *Geocaching*, *Ingress*). In *Recoil*, community participation is invited in a unique way: the company releases the source code of the dedicated hardware built by them, and players can attempt to modify, use it, or release it to other players. Modifications include alteration of haptic feedback or light colours, and the re-usage of off-the-self hardware (e.g. routers, or custom made guns) instead of having to purchase the required hardware. This means that the analysed games consider important the participation of players in the game and their online communities, to sustain and prolong their momentum throughout the years, or simply help other players in enjoying the game play.

Administration: Centralised management and orchestration of gameplay, players, content, and players' contributions, is present in all games analysed. The content offered by several games varies across different locations, and this can be seen when players walk in terrain offering different properties (*Pokemon Go*). This means that the content is offered in a differentiated way, and is often altered dynamically (e.g. rare Pokemons in specific dates). Other games offer unique events that vary dynamically over time, which have to be set up and managed centrally by the game owner (*Ingress*, *Orna*, *Parallel Kingdom*, and *Pokemon Go*). Content, and players, are administered by the game owners when: new content is proposed by players and accepted or not (*CodeRunner*, *Ingress*, *Orna*, and *Pokemon Go*), players' behaviours and disagreements have to be settled (Geocaching), community support is done (*Orna*), and new features are constantly released (*Parallel Kingdom*, *Pokemon Go*, and *Recoil*). Lastly, administration is also observed when the game reveals some form of control, e.g. API control in *Parallel Kingdom*, or the gradual scaling up of a game to other countries (*Ingress*). Beyond the scalability worldwide, management of content, players, and players' contributions and behaviours are shared features across the analysed games, and are essential for their maintenance and player participation.

These 6 key components: positioning of players in their environment (*Augmentation*), direction and orientation of players in space through informational and visual cues (*Navigation*), multi-modal interaction with other players and the environment (*Interaction*), progression of a game (*State Progression*), contribution and involvement of players both at the level of content and maintenance of game play (*Participation*), and the centralised orchestration and management of the game (*Administration*), have shown to be included in the 7 games analysed as shown in table 5.2. As such, these components are considered to be essential for a high-level software architecture for location-based game designed to foster social interaction in public space.

	CodeRunner	Geocaching	Ingress	Orna	Parallel Kingdom	Pokémon Go	Recoil
Augmentation	- 2D Map + information - Content of game is aligned with env.	- 2D Map + icons - List of caches - Content of game is aligned with surroundings	- Content of game is aligned with surroundings - 2D Map with Portals - Teams' regions of dominance on the map - Colours	- Information of land kingdoms, players surrounding the player' s location - 2D Map + icons - Content of game is aligned with surroundings	- 2D Map, colours - Territories owned by players - Icons / monsters around player - Content of game is aligned with surroundings	- AR, 3D Map + animated icons - Content aligned with surroundings - POIs are used , and context of real world offers different types of Pokémons	- Locations for ammunition - Positions of other players - AR missions - 2D Mini map
Navigation	- Icons and info on the map indicate where players need to go	- Compass - Multi-hop cache	- Colours on map - Map shows what is in range - Direction, and magnetic orientation	- Arrows pointing to the direction the player should follow - Text with clue and distance	- Teleportation to discovered places - Icons on the map. Navigation based on their importance	- Magnetic orientation of avatar - 3D icons influence navigation - Speed of navigation influences rewards	- Arrow pointing to enemy or POI - Text indicates distance to enemy or POI - Compass
Interaction	- Audio comm. - Touch, swipe, real objects	- Real-world interaction with objects, touch - Players play offline	- Audio in app - Manipulation of map, zoom, touch, direction change - Offline interaction	- Touch - Offline interaction with other players - Turn-based interaction	- Touch - Offline interaction with players, to trade and battle	- Players come together offline for raid battles - Touch, swipe - Map manipulation	- Haptic feedback, button, touch - Audio positioning - Audio chat, light - Offline play
State Progression	- Task completion, puzzle solving	- Game statistics (quantity of caches solved) - Leader boards - Task completion - Players earn the right to post their cache	- Linking portals, hacking portals - Items, portal keys - Leader boards	- Character levels - Statistics - New items, monsters, modes - Virtual economy - Small missions	- Character level - Resources, food, health bar - Statistics, leader board - Plant resources, defeat enemies, own land	- Quests, - Player, Pokémon levels unlocking new features - Leader boards - Player navigation counts to evolution	- Battle modes, and rules of engagement - Divide and conquer - Health and ammo - Missions
Participation	- Players add mini challenges in-game - Players report bad inputs	- Cache owners answer players - Players manage secrecy - Maintenance and report of caches	- Dedicated authoring tool for new portals - Peer review of players' proposals	- Community contribution of game art and media through authoring platform		- Dedicated authoring platform for proposal of new POI	- Player participation in reusing the game in custom-made hardware
Administration	- Management of drop off points created by players	- Management of caches and player disagreements - Repository of travel bugs and caches	- Events and content created by company - Scale up of game - Contribution revision	- Creation of bosses - Management of content proposed - Community support	- API control - Events, community engagement - Content / feature creation	- Events, unique Pokémons - Review of contributions - Differential content	- New features and content - LAN-based game, players administer play

Table 5.2: Summary of key functionalities of the analysed games.

5.3.1. Modular software architecture for location-based games

Figure 5.3 depicts a modular software architecture featuring the 6 identified key components. It serves as a skeleton for location-based games designed to foster social interaction in public space, and refers to a mobile computing device (MCD), services required to support the game, and a Portal. The hardware (including communication devices, memory, sensor and actuators) and software (including an operating system and libraries) on the MCD are capable of running a mobile game application. NOTE - MEMORY IS NOT IN PICTURE. Services can be implemented by the developers or hired to 3rd party companies, thus enabling their implementation in a modular way. The portal refers to an interface (e.g. local, or web-based) that players can use to submit, and potentially also author contributions to the game.

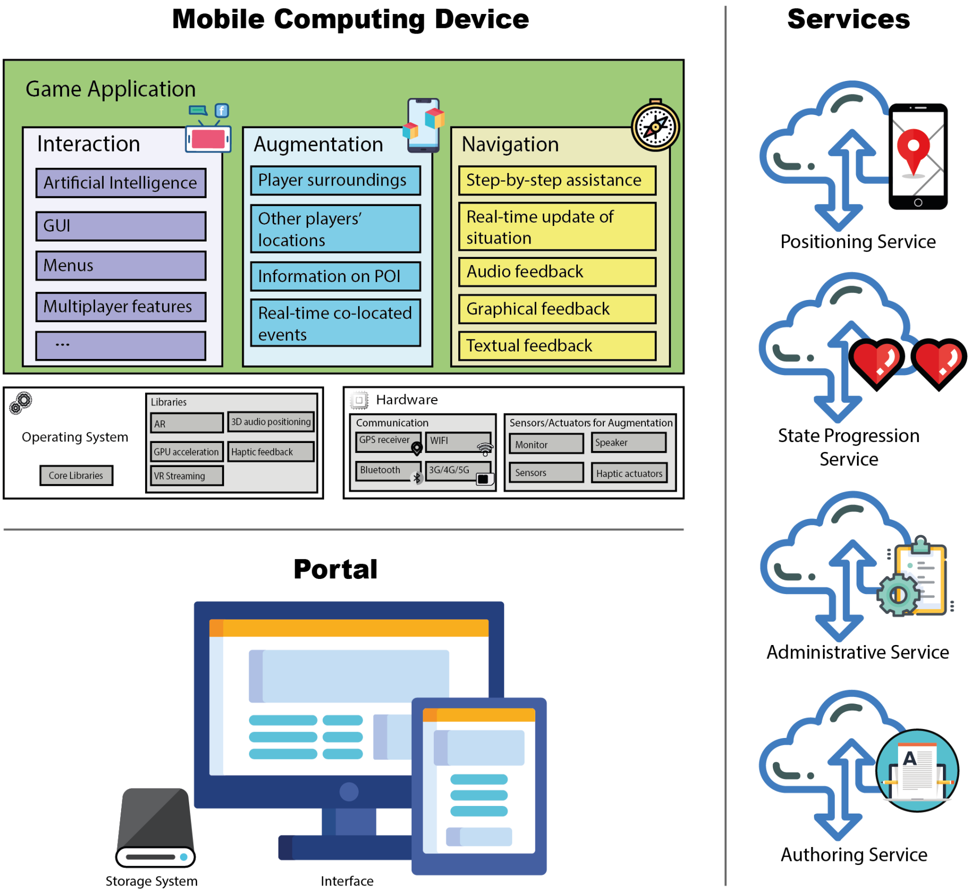


Figure 5.3: Modular software architecture for a location-based game for social interaction. Monochromatic colour scheme represents layers usually not built during game development; Polychromatic colour scheme otherwise.

The 6 key components, defined in table 5.3, are represented in figure 5.3 as follows: the first three components *Augmentation*, *Navigation*, and *Interaction* are inside the Game Application (under the same names); the components *State Progression*, *Participation*, and *Administration*, map respectively to **State Progression Service**, **Authoring Service**, and **Administrative Service**. The key components *Augmentation* and *Navigation* are supported by the **Positioning Service**, responsible for localisation and context awareness services working in tandem with the locative features of the MCD. The **Authoring Service** powers the Portal, i.e. an interface (e.g. Desktop, or webpage) with a storage system that can capture the contributions of players, and that might have authoring capabilities included. The **Administrative Service** enables the access to any interface (e.g. MCD, or the Portal) to administer/manage the game.

Key Component	Description
Administration	Management of the state of the game and all of its components, from statistics, players, and game content. Also included is community support, event creation, mediation of conflict between players, control of the access to the game through APIs, targeting of content to players, and the release of new features and updates. If players contribute content, that content is approved, rejected, or curated by the administrator.
Augmentation	Enhancement of the perception of the player on his/her real-world surroundings and the digital game state. The game positions players in relation to the real world, represents them digitally in relation to a referential (earth), shows other players in the vicinity, and displays areas in the real world where players should attend to in order to advance the game play in their favour. This component makes the game location-aware, and can deploy technologies such as maps or augmented reality.
Interaction	Mechanisms used by players to control or interact with the digital game world. Interaction also includes dynamics of interaction between players offline (e.g. team formation) required to access new modes of play. This component supports the components of augmentation and navigation, and can be based on, for e.g., interfaces based on menus, interaction based on touch, smell, auditory, or haptic, artificial intelligence, brain-computer interfaces, eye gaze, movement tracking, tangible interfaces, and multi-player interaction mechanisms such as voting on content left by other players.
Navigation	Player support in navigation from its current location towards another location. This support needs to be straightforward and successful in providing the player with for e.g. a position, direction, duration of the navigation, and orientation. It should also be effective at providing players with the correct orientation, and disappear when not needed.

Table 5.3 (continued)

Participation	The contribution made by players towards the game, whether it is the content (storyline, individual tasks, or physical objects), community maintenance, or game art media. This contribution allows players to take partial ownership of the game through co-creation, and provides a sustained and prolonged game play fuelled by players themselves. Players are capable of creating and/or manage their contributions via an authoring service or tool that supports their participation in the game.
State Progression	Game-like mechanisms and elements that support gameplay throughout time, enabling players to return to the same state left in the game, to differentiate players' performances, and to create opportunities for dynamics of collaboration and competition. These mechanisms refer to both the inner workings of the game, and the display of the game state to the player: task completion, game statistics (e.g. leader boards, resources, scores), character levels, rare items unique to experienced players, voting for other players' content, different modes of play, and the counting of resources found in the real/digital world.

Table 5.3: Definition of Key Components offered by the software architecture.

5.4. Discussion and Summary

This chapter sought to gather current understanding on what system components are needed to sustain social interaction in public space, so that such key information can be taken into account when proposing a game design that embodies the users' requirements in a way that works. It zooms in on the lack of guidance from a system's perspective that designers and developers face when creating a LBG, and focuses on which architectural components are key for LBGs of this purpose to work.

Commonalities in essential functionality provided by 7 such LBGs have been presented, i.e. functionality without which these games would not be capable of delivering the designed game play. Six key components were identified: *Augmentation*, *Navigation*, *Interaction*, *State Progression*, *Participation*, and *Administration*. These components are key because without them: the game would not be able to represent the environment of the player (*Augmentation*) or assist him/her in the location-based game play that is central to this genre (*Navigation*); multi-modal interaction with other players and the environment would not be possible (*Interaction*); tracking of the interaction with physical/digital objects, the game play, and every game-like progression would not exist (*State Progression*); contribution and involvement of players both at the level of content and maintenance of game play would not be possible, rendering long-term game play of an LBG designed for social interaction obsolete (*Participation*); and the centralised orchestration and management of the game, required for the consistency of the game, would render the game unplayable (*Administration*).

A modular software architecture based on the key components is proposed. The modular software architecture guarantees that not only designers and developers know which components to include, but also that they benefit from a modular approach that grants freedom of implementation. It provides guidance on how to create a system for an LBG that can potentially trigger social interaction in public space, all the while granting game designers and developers with freedom of choice (of how to implement each component) that does not constraint their creativity (through a too detailed method). This modular software architecture supports the six components identified, and can be extended to include other components for other types of functionality as needed.

Chapter 6 presents the applicability of this modular software architecture in a LBG prototype. It presents the game design that incorporates the proposed architecture, and chapter 7 offers a case study where this prototype, which embodies not only this architecture but also the user requirements from chapter 4, is put to test.

6

The Game

It's not that I'm a serious person; I'm playful and stuff like that, but I take characters very seriously and the work very seriously.

Bryce Dallas Howard

This thesis begins with the motivation of impacting social cohesion. In such exploration, this research learned that social interaction is a key requirement for the promotion of social cohesion (Fonseca et al., 2018b). From this requirement (the central requirement in figure 6.1), followed the exploration of LBGs with players engaging 1) within their own neighbourhood, and 2) in meaningful interaction with friends and passers-by. To this purpose, 4 characteristics were identified for the targeted type of gameplay: an LBG that 1) is played with the smartphone, is 2) fun to play, and that 3) involves known and unknown people 4) in the neighbourhood of the player (marked as a 2nd ring on figure 6.1).

This chapter is based on the published article: X. Fonseca, S. Lukosch, and F. Brazier, *Secrets of the South: A Location-based Game for the Development of 21st Century Social Skills and Promotion of Social Interaction*, Proceedings of DELbA 2020 Workshop on Designing and Facilitating Educational Location-based Applications co-located with the Fifteenth European Conference on Technology Enhanced Learning (EC-TEL 2020), Heidelberg, Germany, 2020.
This chapter is based on an appendix submitted together with the article: X. Fonseca, S. Lukosch, and F. Brazier, *Modular Software Architecture for Location-based Games Designed for Social Interaction in Public Space*, 2020 (Submitted to Entertainment Computing Journal, currently in review).

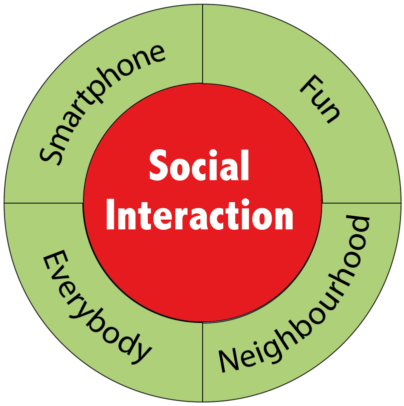


Figure 6.1: Requirement for social cohesion and initial constraints.

6.1. METHODOLOGY

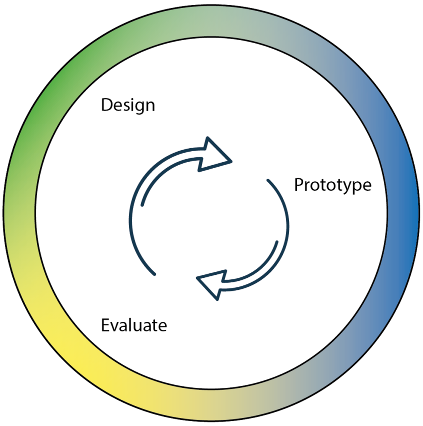


Figure 6.2: Iterative design process followed in the process of game design, development and validation with (potential) players.

The game design presented in this chapter is a product of an iterative design approach (Nielsen, 1993). Research in game design argues that an interactive system requires an iterative design approach with iterations of requirements and (partial) design artefacts/prototypes (Ballagas et al., 2007; Dix et al., 2003; Gould and Lewis, 1985). The specific stages of an iterative approach named in the literature vary (Bailey, 1993; Gossain and Anderson, 1990; Ishii et al., 1994), but all describe a stage in which an artefact is firstly designed, then prototyped, and evaluated/validated[1,2,3]. These 3 steps can be repeated a number of times, until the product meets the designers' goals/mission and system requirements, as depicted in figure 6.2.

The design process for the LBG on which this paper reports took close to two years in duration, and had the following structure:

1. Requirements elicitation from adolescents, in case study 1 (chapter 4.1) (schools of Rotterdams Vakcollege de Hef, and Scheepvaart en Transport College, Rotterdam, NL) (Fonseca et al., 2017).

2. Research on requirements for a systems' architecture for LBGs for social interaction (chapter 5) (Fonseca, Lukosch, and Brazier, 2020a).

3. Design: conceptualisation of initial game design (described in (Fonseca et al., 2018a)).

4. Development of the first game prototype.

5. Evaluation of first prototype in case study 2 with adults (chapter 4.2). Feedback of participants was collected to inform further design and development (Fonseca et al., 2018a).

6. Redesign of the prototype for case study 3: Analysis of required functionality, and learnings from previous steps are used to improve the game prototype (described in (Slingerland, Fonseca, et al., 2020)).

7. Development of the second version of the game prototype.

8. Evaluation of the second version of the game prototype as case study 3 with adults (chapter 4.3) (Slingerland, Fonseca, et al., 2020).

9. Co-design of gaming activities as case study 4 with children (school Christelijke Basisschool De Akker). Outcome is a list of specific challenges (i.e. specific activities, with specific locations in the neighbourhood), to be adapted to the game prototype as content (chapter 4.4).

10. Development of 3rd and final version of game prototype, with the defined game content from previous step, and more intuitive interface.

11. Evaluation of 3rd and final version of the game prototype with children (same of step 9) (Fonseca et al., 2021) (chapter 7).

The products of these stages, organised around the adopted iterative design methodology, are 1) a 4-step general procedure to create LBGs for meaningful social interaction in public space (section 6.2), and 2) the game design of a fully open-source LBG prototype for the identified purpose, 'Secrets of the South' (SotS) (section 6.3).

[1] https://www.enginess.io/insights/what-is-iterative-design, What is iterative design?, last visited on December 23, 2020.

[2] https://www.bipsync.com/blog/iterativeproductdesign/, Iterative product design, last visited on December 23, 2020.

[3] https://www.meee-services.com/why-prototype-iteration-in-a-product-development-is-needed/,Why is prototype iteration in a product development needed?, last visited on December 23, 2020.

6.2. 4 STEPS TO BUILD LBGS FOR MEANINGFUL SOCIAL INTERACTION IN PUBLIC SPACE

Given that the social interaction sought is one that bears meaning to players, this research studied how to design LBGs for such purpose both from the technical perspective and user perspective. From the research methodology described above, 4 steps are recommended as general procedure to design and build an LBG capable of inviting and sustaining social interaction in public space that appeals to players:

- **Step 1.** Discovering a set of game dynamics in which players are interested.
- **Step 2.** Distinguishing types of activities, that a game of this type should be able to offer to children, adolescents and adults.
- **Step 3.** Developing ideas for challenges by potential players involving the activities distinguished in step 2.
- **Step 4.** Identifying the architectural components that are key for such type of games to work.

These 4 steps were taken by this research to create the 'Secrets of the South' (see section 6.3). The process is described in the following way and summarised in figure 6.3:

Step 1 - For the involved players and social context considered, the desired set of game dynamics are: *achievement*, *real-world play*, *reinforcement*, *social interaction*, *collaboration*, *digital interaction*, *ownership*, *winning condition*, *collection*, *exertion*, *virtual representation*, *mission*, *community contribution*, and *lottery*. These dynamics relate to the design of the game world (i.e., the digital game), and are considered to be high-level requirements regarding the functionality of the game: they guide the choice and arrangement of game elements and mechanisms to provide the run-time dynamics of play desired by players (organised in the upper left quadrant in figure 6.3) (Fonseca, Lukosch, Lukosch, and Brazier, 2020; Fonseca et al., 2017).

Step 2 - For the reported goal and setup, 7 types of activities are distinguished: activities that require players to do physical activities (**Athlete**), find information and factual knowledge (**Detective**), explore their neighbourhood (**Explorer**), propose ideas and explore opportunities (**Inventor**), find specific things or people (**Hunter**), create and express thoughts, feelings, interests in some form (**Artist**), and contribute to the environment and help others (Fonseca et al., 2018a; Slingerland, Fonseca, et al., 2020) (**Volunteer**) - upper right quadrant in figure 6.3.

Step 3 - For the studied neighbourhoods in Rotterdam, 56 game ideas were devised, indicating the types of activities that appeal to potential players (see bottom right quadrant in figure 6.3).

Step 4 - For social interaction in public space via LBGs, essential architectural components are (Fonseca, Lukosch, and Brazier, 2020a): **Augmentation**, **Navigation**, **Interaction**, **State Progression**, **Participation**, and **Administration**. These components, offered in a modular software architecture, provide the functionality needed to represent the environment of players, locate them, facilitate interaction with other players/environment/physical objects, track the gameplay state, enable long-term play for players through contributions, and manage the game (see bottom left quadrant in figure 6.3).

Figure 6.3 summarises the 4 steps recommended as general procedure, together with the major requirement and characteristics identified in this study. From the methodology reported (out of which these 4 steps emerge), a game concept was then developed based on what players prefer, want, and desire to play in their own neighbourhood. This concept is an actual game prototype that is developed and tested in chapter 7. This game concept is described next, and the design choices that were taken are discussed after.

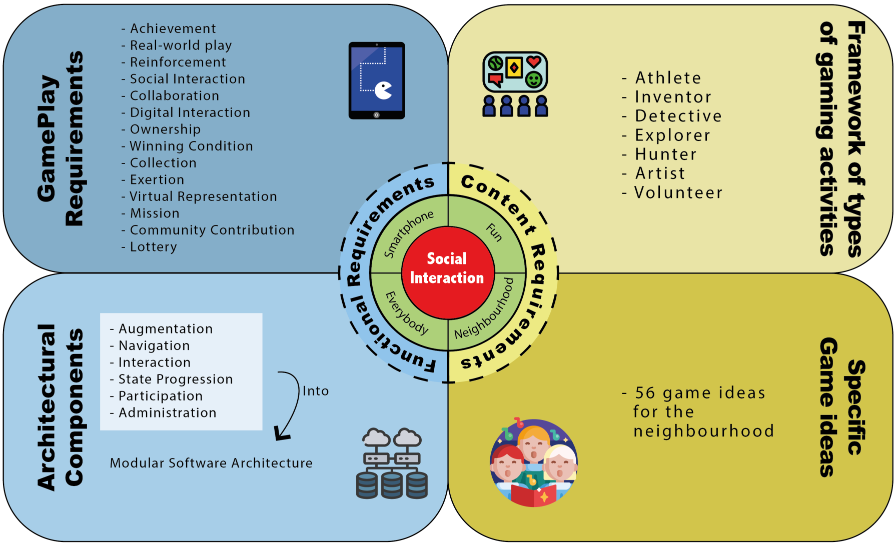


Figure 6.3: Information for the creation of location-based games for social interaction tailored to the public space surrounding users: user-centred requirements, and key architectural components.

6.3. GAME DESIGN: SECRETS OF THE SOUTH

The game 'Secrets of the South'[4,5] (SotS) is a pervasive location-based game that uses smartphones to mediate outdoor activities (called challenges) for social interaction. Players are presented with challenges to enable them to engage with both strangers, friends, or other players, walk around outdoor public spaces in their neighbourhood, and search for solutions to complete challenges and advance in the game (figure 6.4).

[4] http://secretsofthesouth.tbm.tudelft.nl/, Secrets of the South, last visited on December 23, 2020.
[5] https://github.com/xavierfonsecaphd/SecretsOfTheSouth, Secrets of the South source code, last visited on December 23, 2020.

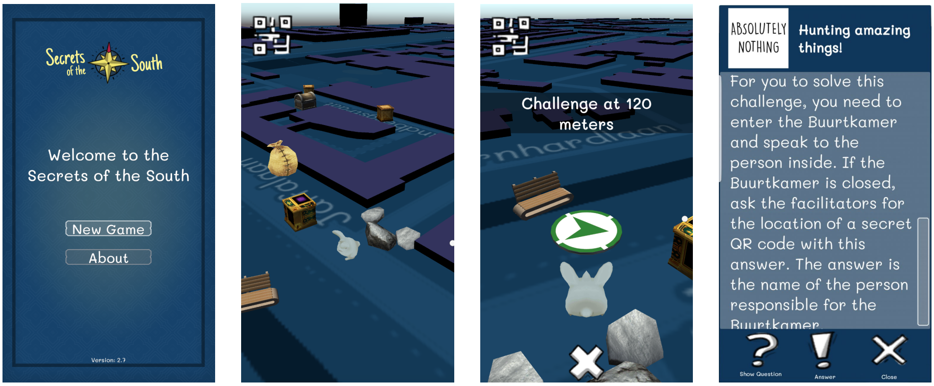


Figure 6.4: In Secrets of the South, challenges allow players to encounter people or locations that otherwise stay unnoticed (Slingerland, Fonseca, et al., 2020).

These challenges are designed to foster social interaction both in the real world (e.g. in the form of face-to-face communication with others, or physical contact such as shaking hands), and in the digital world (e.g. exchanging messages and images left behind in the neighbourhood through QR codes). These challenges provide players with opportunities to encounter and engage with other people in their surroundings, and are strategically located to expose players to both places and local activities often unnoticed around the neighbourhood (e.g. local heroes, or the most important landmark in the country). Players can scan other players' QR codes (i.e. their identities) to acquire points in the game, and to count other players' friendships. Points represent the players' progress in the game, relating to both the number of challenges solved and to the number of players befriended. The SotS is a pervasive game that shows the real surroundings of the player (always represented by a rabbit). The player has access to a 3D map of the surrounding environment (figure 6.4.b and c), and can see animated 3D icons that represent the challenges h/she can do on the map (these are rotating around themselves). When players tap on the screen, on top of the 3D icons representing the challenges, but are too far from the challenge's location (50 meters), a message is displayed saying that they need to walk closer to the challenge. If they are close enough the location of the challenge, a new screen containing the information about the challenge and what players have to do to solve them is revealed (figure 6.4.d).

The game provides a degree of configuration and flexibility. Common functionalities of the game can be accessed through a menu placed on the main screen, which triggers a drop-down set of options that allows players to access the main menu, access a list of challenges surrounding them, visualise the team of the player, show the player's QR identity, and open up the QR reader (figure 6.5.a). Inside the main menu (figure 6.5.b), players start off by seeing their avatar and their statistics (which include how many players they scanned the QR codes, number of challenges solved, number of challenges where the player was the first to solve, amount of gold, and how many challenges did the player create himself in the SotS online game platform). Players also have access to other important sub-menus, such as the leader board of people met (which indicates which players interacted the most with the game by scanning individual QR codes) (figure 6.5.g), the teams that have the most multiplayer challenges solved, and the settings menu (figure 6.5.h).

Figure 6.5: Common functionalities of SotS. Figure a - top left) shows the dropdown menu containing options, b) the Main Menu (to the right of Figure a), c) the list of challenges surrounding the player and their distance, d) the team of the player, e) the player's QR identification (bottom left), f) the QR reader of the game (to the right of Figure e), g) the rank of players' interaction, and h) the settings menu.

In the list of challenges, players can see which challenges are surrounding them at the time, and the distance they are to each of them (figure 6.5.c). In the team of the player sub-menu (figure 6.5.d), players have at their disposal the possibility to visualise the team they are currently on (which includes a name and a team crest randomly generated by the game), remove their association to that team, or create a new team. In the player's QR identification sub-menu (figure 6.5.e), it is shown a QR code that is unique to the player, and that serves the purpose to be scanned by other players. When players scan each other's identification QR code, the game increments one interaction for both players (labelled as

"People Met"). Players can also scan any QR code related to the SotS in the last option of the drop-down menu (figure 6.5.f), which enables players to interact with other players and count such encounters, join other teams already formed, and solve challenges that are solvable by finding their specific QR code. These challenges can also be solved by making players find objects containing QR codes, which allows for a treasure hunt dynamic.

In the settings menu (figure 6.5.h), the game allows for players to set a different language, change their avatar picture (by copy-pasting a different URL that players can find on an online search engine), set the maximum distance in kilometres that the game should scan for nearby challenges, flush permissions of the player (in case a players received them from the administrator), and to delete that player's account from the game (the game only asks for login credentials once at the beginning, and this option allows for a change of player).The game is available in English, Portuguese, and Dutch. It can be downloaded both from the Google Play Store[6] (for the mobile game application, with the existent background server running inside TU Delft's premises at the time of this writing[4]), and the GitHub repository[5] (for the entire source code, publicly available).

6.3.1. FUNCTIONAL CHALLENGE TYPES

The SotS offers different sorts of activities to players, and these require different functionalities from the game. The game offers 6 functional types of challenges for players to solve (different from the framework of types of activities of chapter 4): Quiz, Multiplayer, Timed Task, Hunter, Open Quiz, and Voting. These functional types involve different game mechanics, and require different things from the player to be marked as completed. The type Quiz asks a closed question (e.g. "In which year ..."), and expects a closed answer (e.g. "1987"). Multiplayer aims to facilitate group-based game play, i.e., in-group interaction between players and their friends. Challenges of this type ask players to perform a task (e.g. "Jump up and down 10 times at the same time") in the presence of an external facilitator. Timed task presents players with a challenge (e.g. "High-five at least 6 people under 2 minutes"), and this needs to be solved within a time frame (figure 6.6.d). The type Hunter asks a closed question (e.g. "What is the agenda of the cinema for tonight at 20h? Go ask at the counter."), but enables players to also mark the challenge as solved by scanning a QR code in the environment (figure 6.6.a). The type Open Quiz is suitable for open questions (e.g. "What do you think of this neighbourhood?"), because they allow for players to give any answer and always marks the challenge as successfully solved (figure 6.6.b). Lastly, the type Voting makes players solve a challenge by taking a picture, and uploading it to the challenge. Once that is done, players can access the pictures that previous players uploaded to the game, and leave their vote behind (figure 6.6.c).

Most type of challenges that the SotS mediates are completely managed by the game. When opened, these ask something from the player to be marked as solved (an answer, or a task like taking a photograph and uploading it into the game, or even scanning a QR code from the environment). Upon the introduction of the solution (closed answer, an open answer, a picture, a vote on other player's picture, or a number), the game validates the expected answer (if there is one), and attributes points to the player for the completion of the challenge (5 points for incorrect or almost correct answers, 10 points otherwise).

[6]https://play.google.com/store/apps/details?id=com.Xav13rua.SecretsOfTheSouthv2, Secrets of the South, Google Play Store, last visited on December 23, 2020.

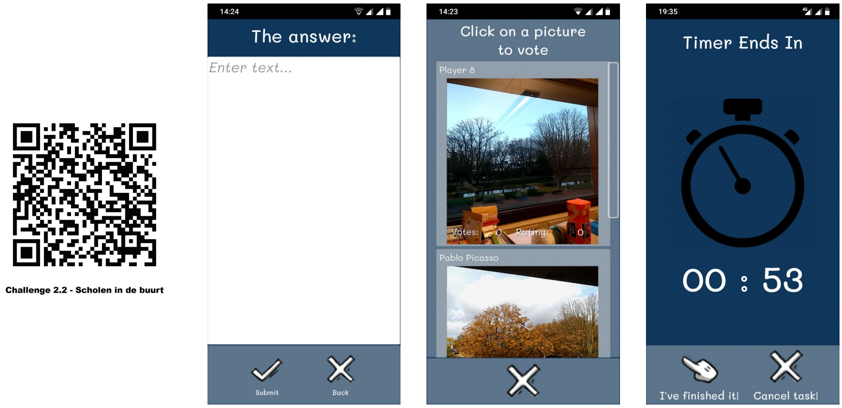


Figure 6.6: Game Challenges. a) Example of a QR code placeable in the environment. b) Answer area of Open Quiz. c) Solutions of a Voting challenge. d) Timer of a Timed Task.

The Multiplayer type of challenge cannot be automatically validated in-game as the other types. It involves a performance of a group of players playing together, and only an external observer is capable of validating the completion of the task for every player involved. This type of challenge only appears in the player list of challenges when h/she is in a team. Once a team is formed, players can navigate towards this type of challenge and access its content. However, these challenges do not provide an answer box. The way these challenges are marked as solved is by having external game facilitators in the location of the challenge, observing the group's performance, and evaluating it in the game application.

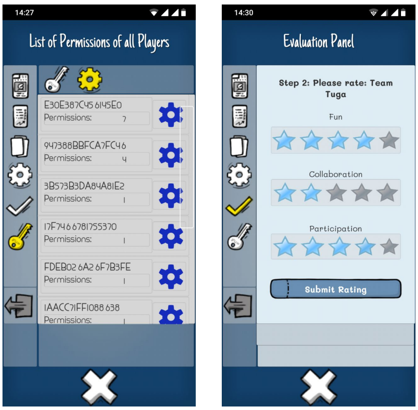


Figure 6.7: Evaluation in Multiplayer challenges. a) Permissions of players. b) Evaluation of team's performance.

To do this evaluation, a facilitator needs to have a SotS account with elevated permissions only attributed by an administrator of the game (figure 6.7.a). Once with those permissions, the facilitator has access to a hidden sub-menu for the evaluation of teams, and can scan that team's QR code to rate its performance. The facilitator's subjective evaluation assesses the levels of fun, collaboration, and participation that h/she observed in the group during the completion of the challenge (figure 6.7.b). After a successful evaluation, the team's performance is updated in the overall board of teams that is present in the main menu. This update is done by computing an average of all three elements assessed.

6.3.2. PARTICIPATORY SYSTEM

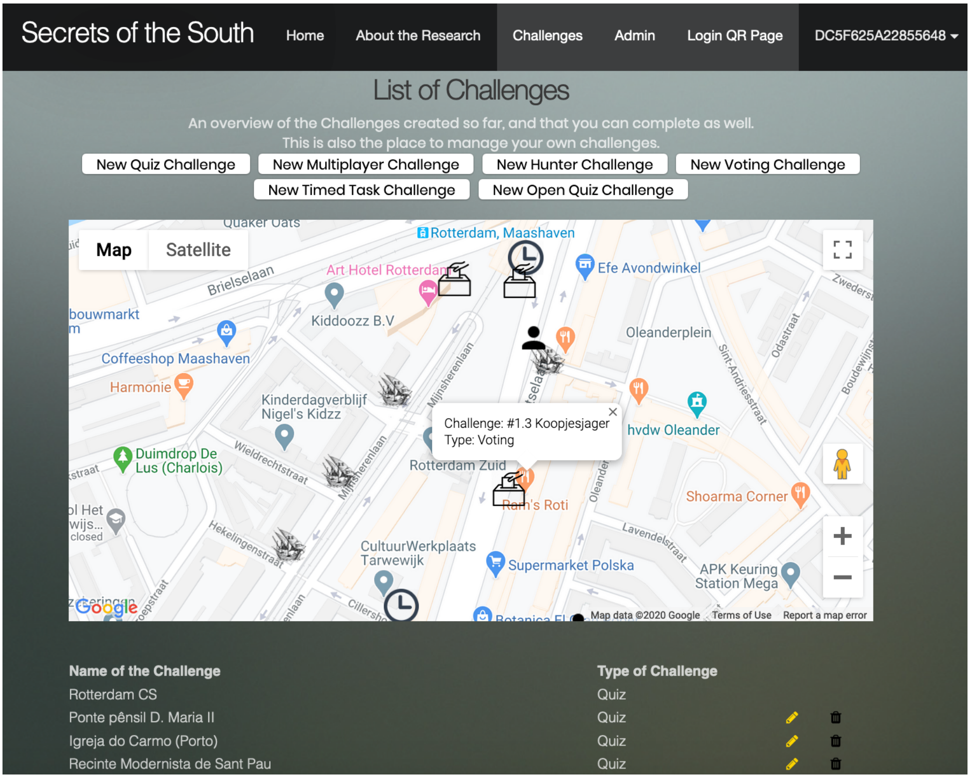


Figure 6.8: Participatory system, and the visual exploration of the location of challenges.

A key feature of the game is its ability to enable players to contribute with content to the game, by being able to use a participatory system online to create challenges for other players to solve. This makes players author their own challenges, partially own the game, and promote a longer-term gameplay.

In this system, the administrator can create new accounts for players (or anyone) to go online and create challenges for players to play, or do this by him/herself (process of account creation is described here[5]). Any player that is not the administrator can create challenges, and see and manage his or her own challenges only. Every time a new challenge is created by a player, an email is sent to the administrator saying that a new challenge was created. The administrator then has to log into the system and manually approve the new challenge. This is a security measure that gives more control over the content created within the SotS (e.g. language used), which might be needed for certain target groups (e.g. younger adolescents). Contributors have access to a map where they can zoom in and out to find challenges across the whole world, and scroll down to see the entire list of challenges currently introduced in the participatory system. Players can click on the icons of challenges that the map shows, and the system reveals the type and name of the challenge that that icon represents (figure 6.8).

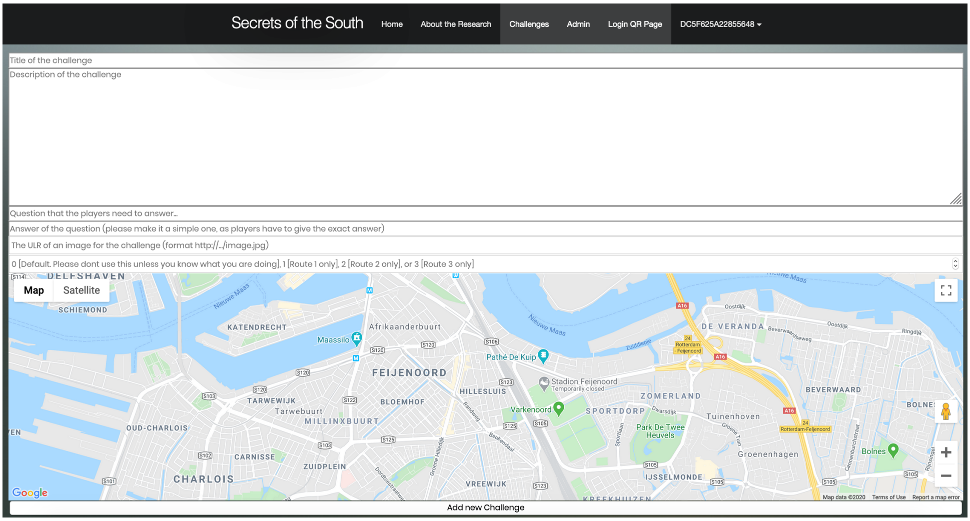


Figure 6.9: Introduction of a new Quiz challenge into the SotS participatory system.

The participatory system allows for players to introduce one of 6 types of challenges, each of which requiring different information to be successfully introduced into the system. In figure 6.9, it can be seen an example of the type of information that is required for the player to fill in for a Quiz challenge: the player clicks on the map to place the location of the challenge, gives a title and a description for the challenge, and a question that the player should answer. This type of challenge requires a closed answer, and this should be introduced here (later validated by the game). The user also needs to introduce a URL link for a picture that h/she wants the player to see in the game's window that shows the challenge. This URL can be found using an internet search engine such as DuckDuckGo™© or Google™©.

Lastly, the user can stipulate if this challenge should only appear to players doing a specific route (e.g. for a research case study, where participants are fragmented and attributed to up to 3 different routes). If zero is introduced, all players can see the challenge, otherwise the challenge will only be seen by players doing a specific route (this can be specified when introducing a challenge in the system, with three possible routes available - 1, 2, or 3 - or no route-specific challenge at all - 0). Other types of challenges have different details being asked (e.g. if a text or image should be shown in the game when scanning a QR code in *Hunter* challenges, or what is the time limit to solve a challenge in *Timed Task*). However, the dynamic of introducing a challenge into the system is the same.

6.4. DISCUSSION OF DESIGN CHOICES

The design choices taken throughout the implementation of the game are influenced by the findings of chapters 2 to 5, which had direct influence in 1) the functionality developed to support the game, 2) the game world, 3) the content designed for the game, and 4) all the system components required by the 'Secrets of the South' to successfully support the designed game play. These design choices are further detailed in the following subsections.

6.4.1. INITIAL REQUIREMENTS

As shown in figure 6.3, the initial requirement is the development of a game that can trigger social interaction (chapter 2), and do so while exposing people to the neighbourhood. This led to the selection of the game genre location-based games, which are digital games that use mobile technology with sensors and wireless connectivity to provide a pervasive game experience. Still, to bring people to the street and interact, this research set 4 constraints based on the lessons learned from chapter 3: 1) to be played with a smartphone, 2) in the neighbourhood of the player, 3) in a way that can involve everyone located in the neighbourhood, and 4) in such a way that is fun to players (and ideally to everyone involved). These constraints stem from the background check on existent location-based games that are capable of triggering dynamics of play that invite citizens to engage with their surrounding environment and have social play. The numerous examples of LBGs mentioned show that fun is a strong factor making people engage in play, which, when leveraged with the already ubiquitous presence of the smartphone, provide inclusive and pervasive gaming experiences that are enjoyed by players around the world. The affordances from these LBGs represent a means to bring people to the street and potentially engage in interaction, and justify the design choices of this research of using LBGs with smartphones in the public space of local communities.

6.4.2. IMPLEMENTATION OF FUNCTIONAL TYPES OF CHALLENGES

Several of the lessons learned from chapter 4 influenced the choices of which functionality the game SotS should have. Knowing the types of activities that users want to play (from the framework of types), and having a pool of specific game ideas to adapt to the game, such information led to the implementation of what it is referred in this thesis as functional types of challenges: challenges offered by the SotS for players to solve and that are based on specific functionality asked by players. The functional types of challenges (*Quiz*, *Multiplayer*, *Timed Task*, *Hunter*, *Open Quiz*, and *Voting*) are implemented based on the framework of activities and the specific game ideas users gave, which shed light on the functionality that the game should have to support a specific idea. The functionalities required, and design decisions made to implement them, are justified per functional type of challenge:

Quiz Challenges:

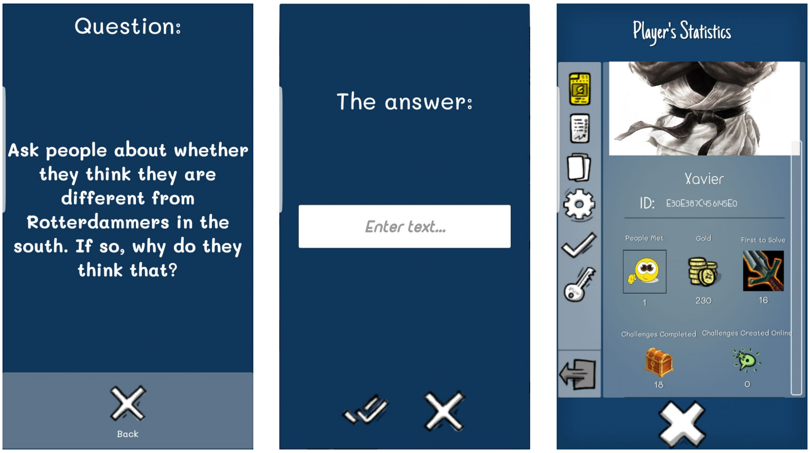


Figure 6.10: Design choices with the Quiz challenge (Question - left, Answer - middle, point attribution - right).

The Quiz challenge is materialised from the Detective type of activity, and the ideas fitting this type. Users mentioned wanting to ask specific questions (e.g. "How long does the school exist? Ask somebody for the answer"), and this requires the implementation of a mechanism capable of prompting players with a closed question, providing a way for players to introduce an answer, and validate if such answer is correct or not. This also justifies the decision of implementing a reward system based on whether the answers given by players are correct or not, to inform players on the quality of their answer. Another decision made in the implementation of the Quiz challenge is the ability for players to re-take a quiz challenge that they failed to answer in a right way. In such case, the challenge is not marked as solved. With regard to the point attribution, it was decided to attribute points for the correct answer, and count the quantity of challenges successfully solved (see figure 6.10).

Lastly, based on collected feedback from one of the case studies done, players revealed that not getting an answer right did affect their engagement in the game. As such, a design choice was made to still attribute a half amount of points per wrong answer. This can lead players to attempt to cheat the system by keep introducing wrong answers, but given the purpose of the SotS (social interaction in public space, through a fun-based gameplay), this is not a problem.

Multiplayer Challenges:

The users were clear with regard to wanting to perform physical activities, which led to the type of activity *Athlete*. This specific type of activity (e.g. doing parkour, communicating without talking, or run with the metro) is difficult to convert into a digital activity that can be tracked purely with the smartphone (like the *Quiz* challenge). Not all activities can be tracked with GPS (e.g. going from point A to B), and might be solved between multiple players simultaneously (making validation even harder). Even some activities of the type *Artist* require the performance to be observed (e.g. to create music), and require a mechanism of marking these challenges as completed that is different from pure validation of text.

Figure 6.11: Design choices with the Multiplayer challenges (a - team creation, b - the task window players see in multiplayer, c - user permissions, and d - rating of a team's performance).

As such, the first 2 design choices for this challenge are the request to have players perform a task (instead of giving an answer - figure 6.11.b), and the need for them to form a team to do this task or performance. Justifying this is the fact that the ideas given by users involve a joint performance (e.g. race against one another), which makes these challenges inherently multiplayer. Players can create a team by giving a name to it, and the game suggests a random avatar for the team. Then, the player creating the team is shown a team QR code, which can then be scanned by other players to join that team (a player can only be part of one team).

Another design choice in this type of functional challenge was to not validate the performance of players in their account, but to set up external validators (workshop facilitators with a player account) by the location where such performances had to be done by players. This meant the implementation of user accounts with different levels of access (regular player, evaluator, and administrator), and the creation of a way for users acting as evaluators to rate a performance. When a team of players finishes the required performance, one member of the team shows the team QR code to the person evaluating the performance, and h/she assesses the team's performance with 3 criteria: fun, participation, and collaboration. The rating given on each of the criteria (from 1 to 5 stars) is then used to calculate one overall score to be added to all the elements of that team, plus one challenge completed. The criteria used for validation is a subjective method dependent on the perspective of the evaluator, but it is not meant to be more meaningful than adding a way to validate the completion of these challenges and differentiating the performance of each team for ranking purposes. The role of the administrator was added to the game in order to allow for a dynamic attribution and removal of the evaluator roles to/from different players, during the game play: the administrator does this management of attributions. Both the roles of evaluator and administrator have access to more menu options than what it is shown to the role of regular player.

Timed Task Challenges:
Part of the ideas that users gave in specific to the type *Athlete* require the track of time. Ideas such as "how long does it take to...", "find within one minute 10 people that ...", "how many ... can you make within 1 minute", and "be the fastest at...", all require two specific functionality to be developed: 1) the countdown of a predefined amount of time, and 2) the tracking of how much did the player do or collect. Therefore, these ideas require more functionality that is not provided by the previous two challenge types *Quiz* and *Multiplayer*. A *Timed Task* challenge is created in the game: this is a challenge that can be done by one player (no need for a team), that invites players to do a task within a given amount of time. When players encounter this type of challenge on the map, a window is offered where they can read the question, and another that offers a way to start the timing whenever players are ready to start the countdown. During this countdown, players can cancel the countdown, click to stop the countdown and introduce their input, or simply let the countdown finish. As the next step (the tracking of how much did the player do or collect), the game offers a way for players to introduce a number. The design choice taken here is that the game does not offer a mechanism of validation, and just accepts a number with a quantity of how many "things" players did/collected. The reason for this is that offering a more meaningful validation would require a much more complex process of double checking whether the payer actually performed, which would hardly be solved with one external facilitator alone.

Figure 6.12: Design choices with the Timed Task challenges (a - main window inviting for the task, b - window initiating the challenge, c - timer countdown, and d - the how many question at the end of the challenge).

When the player finishes the *Timed Task*, h/she gets a predefined amount of points (e.g. 10 points), which are then added the number of things the player did/collected on top. As an example, if the task were for the player to convince at least 5 people within 2 minutes to use the bicycle instead of the car, and if the player upon completion introduced 7 people, h/she will get 17 points. This design choice for this type of functional challenge makes the game blindly trust the honesty of players, which of course can invite dishonest play. Still, as the purpose of the game is for players to have fun while being invited to have nice interactions throughout the neighbourhood, that potential foreseen consequence is not substantially harmful to the gameplay.

6

Hunter Challenges:
The type of activities *Hunter* from the framework translated to new functionality in a straight-forward way, leading to this type of challenge. The ideas users gave that fit into this type require players to 1) find specific objects in the environment (e.g. a specific flag, or a tile on a wall), and to 2) learn more about that object (e.g. which flag hangs here, or the biography of a soccer player whose name is engraved on a tile). As such, this type of activity requires players to ask around for information concerning the meaning of a given object/topic, which led to the first design choice of validating this type of challenge in the same way as *Quiz* (the introduction of an answer to a closed question). A second design choice was the usage of QR codes so that players can figure out about a given object in case no one is around to find the required information.

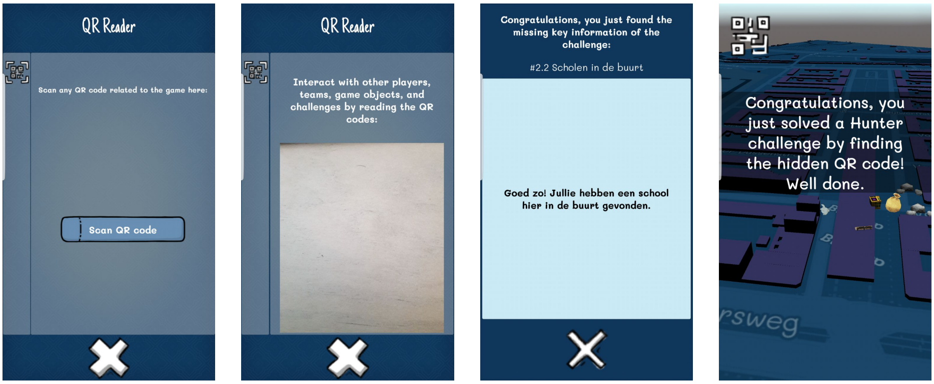


Figure 6.13: Design choices with the Hunter challenges (a and b - activation of QR reader from main menu, c - text message from a specific Hunter challenge QR code (schools in the neighbourhood), and d - message of recognition that a QR code of this type of challenge was found).

These design choices are justified because one of the ideas were converted in a case study to find out more information about what is done at a specific community centre of the neighbourhood: in this idea, players should find out about the agenda offered by this centre, and answer a specific question of "what happens at 8 p.m. on Fridays?". The answer (e.g. game night), which is given by a person working at this centre, might not be possible to get at all times. This led to the creation of QR codes that can be glued to the door of the community centre, and can trigger the game to show the entire agenda for players to seek the correct answer. This motivated the implementation of the display of either text or image to be shown while scanning the QR code attached to an object, and, as the objective here is to expose players to the neighbourhood, the *Hunter* challenge gets solved when 1) players spoke to a person and introduced the correct answer, or 2) when they simply scan the QR code (without further validation). This means that the main dynamic of solving *Hunter* challenges is the one of finding a specific person that can help the player out, and this is what is shown to players in the challenge window that pops up in the main screen (the possibility to introduce the correct answer to the challenge, identical to what is shown for the *Quiz* challenges in figure 6.10). On top of this, *Hunter* challenges can also be solved by finding a QR code, which is scanned through using the QR reader from the main drop down menu. Figure 6.13 shows the implemented flow of solving this type of challenges by scanning QR codes, which was chosen to be integrated with the already existent QR Reader for all other types of QR codes offered within SotS (e.g. Player ID, and Team ID). With these design choices, players can play the ideas where they solve challenges by finding a specific object, all the while learning more about the neighbourhood even when no one is around to communicate such information in person. They also allow for players to inquire passers-by in the neighbourhood about important objects spread across the neighbourhood (e.g. "ask people to come up with 3 names of soccer players from the neighbourhood and find their tiles"), which in turn can be found and marked as solved around the clock.

Open Quiz Challenges:
Several ideas of activities from the users fitting the types *Artist* and *Explorer* indicate that new functionality needed to be developed in order to capture the thoughts of players in an open way. So far, challenge types like *Quiz* and *Hunter* ask closed questions of players, and these, in turn, have to introduce a very short and specific answer to be validated. Yet, users mentioned challenges such as "write a poem about the neighbourhood", "come up with ideas for new street names", "for what is ... used", which all of them invite open answers (i.e. have a varying length and no specific answer).

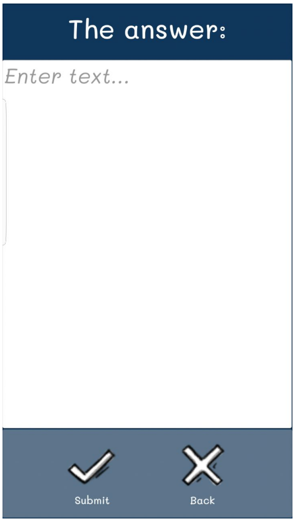


Figure 6.14: Design choices with the Open Quiz challenges.

As such, these ideas required the development of new functionality that allowed players to introduce any sort of text content into a challenge, and mark this challenge as completed as soon as that content is put into the game (with no further validation). This led to the design choices of creating a new functional type of challenge (named *Open Quiz*), the display of a full screen answering box (figure 6.14), the marking of the challenge as solved as soon as the player introduces his/her answer, and, given that it is likely that the information is valuable and should be collected for future analysis, the answers given are stored in a database and sent via email to the administrator of the SotS game (in case further analysis of the game play, during play or after, is desired).

Voting Challenges:
The specific ideas from the users fitting the activity types of *Artist*, *Inventor*, and *Volunteer* required new functionality not implemented with the other functional types of challenges. In specific, ideas such as "make a picture", "come up with a colour scheme for the square", "painting", and "make a plan to ..." all require the ability to either take a picture of something that players find interesting, or to document a creativity-based artefact (e.g. drawing, painting, sketch, or schema). In a few of the ideas of the *Volunteer* type it is also possible to see the usefulness of being able to document the performance of players in, for e.g., picking up trash, or carrying someone else's bag. Thus, these requirements led to the design choices of implementing a new type of challenge (*Voting*), which prompts players to do something, take a picture of it (or simply take a picture of something already existent), give a name they want to attach publicly to the picture (can be theirs, can be anything they want), and upload it into the game. The design choice of allowing players to attach any name they want to the picture is to allow the participation of players that rather prefer having their identity/name kept private. Pictures uploaded into the game are attached to that specific challenge as a solution, and players get the challenge marked as solved once they submit a picture as the answer (which, similarly to the other challenges, gives points to players). Only when a *Voting* challenge is marked as solved (by having the player submitting a picture) can the player see all the pictures that other players submitted to that challenge in particular. Given that this is a location-based game, this detail also motivated the design decision to only show the solutions of that challenge when the player is co-located to the challenge.

When players submit their solution to the challenge and are then able to see the solutions of other players, they can browse these pictures, see the names of their authors, and vote for them (not for their own picture). The voting mechanism is a design choice motivated by some of the ideas that are either competitive in nature (e.g. "the person who collects the most litter wins"), or promote the ideation of an improvement for the neighbourhood (e.g. "increase attractiveness of the location by ...") which, in the future, can actually inform policy makers on how much players liked a given idea. It was not implemented any point attribution for giving a vote.

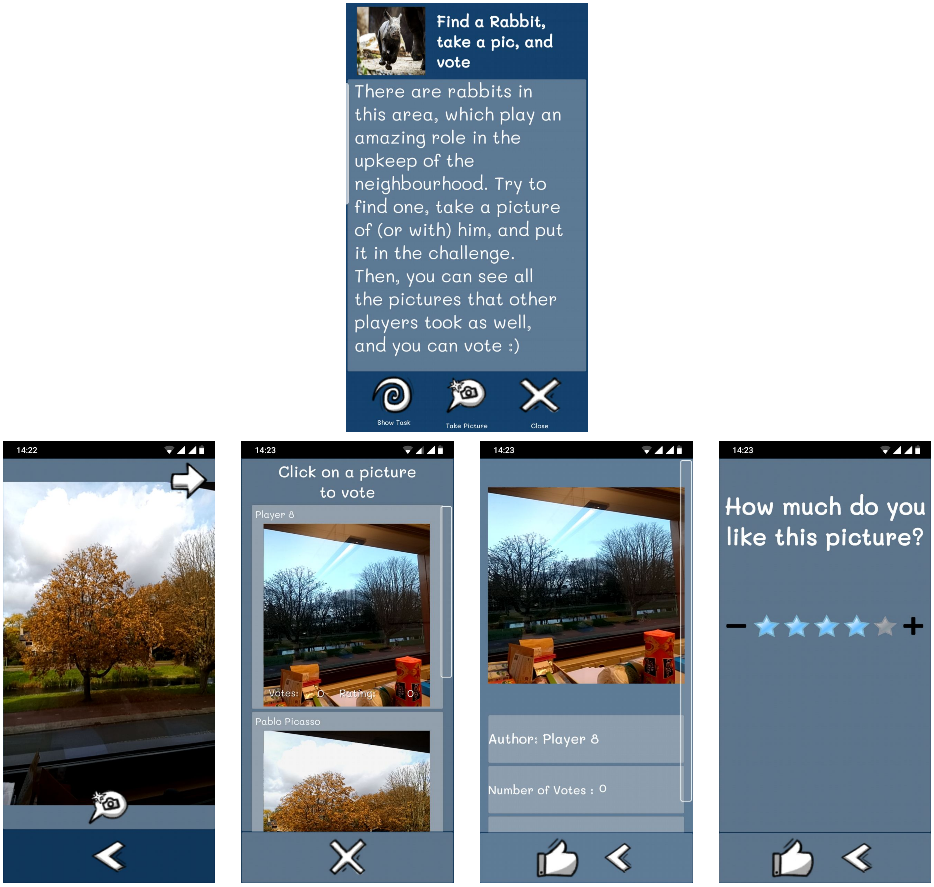


Figure 6.15: Design choices with the Voting challenges (a - main challenge window (top), b - functionality of taking a picture (bottom left), c - solutions given by all the players to this challenge (right to figure b), d - the details and votes of one picture, and e - voting for a picture).

6.4.3. IMPLEMENTATION OF GAMEPLAY REQUIREMENTS

The list of 14 game dynamics taken by this research as gameplay requirements (*Achievement*, *Real-World Play*, *Reinforcement*, *Social Interaction*, *Collaboration*, *Digital Interaction*, *Ownership*, *Winning Condition*, *Collection*, *Exertion*, *Virtual Representation*, *Mission*, *Community Contribution*, and *Lottery*) is a sorted list that provides an indication to game designers and developers for what they should prioritise. It is a list that involves substantial implementation and careful planning during the design of a game, which, depending on the time and effort involved, might not be possible to be implemented entirely or coherently under one game idea. As a game developed throughout the better part of 2 years, the SotS contains design choices that implements all of the 14 dynamics, and these are explained next (sorted by order of importance, first being the most important to users - see section 4.1):

- ***Achievement***: The SotS aims at providing a sense of achievement by offering small challenges that can be quickly accomplished. When players solve a challenge, the game displays a message of "Congratulations, you just solved a ... challenge. Well done.", and get attributed points even when they introduce a completely wrong answer to a closed question (in such case, half the points, for the recognition of the player's attempt).

- ***Real-World Play***: The entire SotS game is designed to be implemented in the public space of the neighbourhood of the player, as the GPS being a technology used that sets a constraint in itself (does not work indoors). This, together with the fact that each challenge offered by the game is designed to be played around the neighbourhood, invite a game play centred in the real world. On top of this, most functional types of challenges really stress the physical activity component, without which players cannot find the answers or complete challenges.

- ***Reinforcement***: The SotS aims at fostering play and engagement by implementing the attribution of badges, points and gold, which are associated with 1) the successful completion of challenges, 2) how many people the player met (by scanning other players' ID QR codes), and 3) the creation of challenges for other players to solve. A few of the statistics of each player change its icon (badge) based on how high their numbers are: for e.g., the number of people met (figure 6.10, right) changes from a normal smile to a wider smile based on how many people the player crossed paths with (and scanned the QR code).

- ***Social Interaction***: The challenges offered by the game are designed for the involvement of both other players (playing together as a group of friends) and passers-by on the streets. This is set by requiring players to for e.g. speak to random people to find out about specific information, or activities where players need to form a team to complete a performance.

- ***Collaboration***: The *Multiplayer* type of challenge is one measure implemented in the SotS to invite collaboration across players. They have to form a team in order to have access to this type of challenges: without a team, the challenges that are listed within a given radius from the player's location do not include Multiplayer ones. Only when a team is formed, the player receives a list of Multiplayer challenges surrounding him/her and his/her fellow team members. On top of this design choice, collaboration is also more subtly proposed in specific challenge ideas where some sort of brainstorm or engagement with strangers is required. In the former case, ideas such as creating a poem do invite discussion in-between a group of players for the best poem, and, in the latter case, peer group support can help less extrovert players in such engagement.

- ***Digital Interaction***: This form of interaction is implemented with asynchronous message exchange through QR codes attached to the *Hunter* challenges. Players can leave messages behind within these QR codes, which are then scanned and seen by other players. Another form of indirect digital interaction is through the voting mechanism of *Voting* challenges: voting a picture does provide feedback to the creations of players. Lastly, digital interaction also occurs when players have to scan each other's QR codes, both to increase the number of people met, and to form a team of players.

- ***Ownership***: This game dynamic is implemented through the online participatory system that allows players to introduce new challenges into the game. By doing so, players own part of what is shown in the SotS to players, as they share potentially unique knowledge about the neighbourhood with the community of players.
- ***Winning Condition***: Competition as a dynamic is set in the game firstly with the *Timed Task* challenges, as it allows for competition for the fastest performances. Also, the game offers points and badges throughout the gameplay, which places not only players but also teams of players in leader boards seen by every player.
- ***Collection***: This dynamic is indirectly implemented with the possibility of searching for real objects and scanning their QR code (of *Hunter* challenges). These QR codes are not meant for players to trade or own the objects, but to allow players to advance their condition in the game by completing challenges, getting rewards with it, and climbing the leader boards.
- ***Exertion***: The SotS invites players to do activities involving physical effort in *Multiplayer* challenges, which often require exertion (e.g. do parkour). More indirectly, challenges involving physical performances (e.g. being the first at spotting a white license plate) or talking to at least a given number of people within a time frame (e.g. convince 10 people to travel by metro within 2 minutes) also invite players to rush around the environment.
- ***Virtual Representation***: The SotS implements an avatar, which is randomly attributed to players when they first enter the game. This avatar can be changed by the players by going into the settings menu, and introducing a URL of an image that can be found via an internet search engine (and copy-pasted into the game). This allows players to represent themselves in the way they wish to.
- ***Mission***: The entire SotS is built around small "missions" or challenges that fall within the common theme "Secrets of the South", meant for players to find the secrets [of Rotterdam] and engage with the neighbourhood and its citizens.
- ***Community Contribution***: The challenge designs offered by the SotS, which are 1) based on what users want, and 2) tailored for social interaction in public space, include passers-by, but also the improvement of the neighbourhood. This improvement is done by for e.g. cleaning trash on the street or having players doing volunteering such as carrying bags for people, which are implemented within *Voting* challenges.
- ***Lottery***: Serendipity is indirectly implemented in the game by allowing players to add new challenges to the SotS. This means that players never know when new challenges are available in the game until they open the mobile application to play (or go to the online SotS portal and zoom into their neighbourhood).

6.4.4. SEPARATION OF CONTENT FROM FUNCTIONALITY

One of the design choices of the SotS was is implementation of an online content management system (CMS), which, from the lessons learned from chapter 5 (the essential modules of participation and administration), made this CMS be named SotS participatory system

6

(figures 6.8 and 6.9). A justification for the creation of a CMS is the need to separate the content of the game from the development of the hard-coded functionality leading to the game. Different challenge designs had to be prepared and offered per case study (e.g., those reported in 4.2 and 4.3), and having such design choice of separating the challenge designs from the hard-coded functionality enabled a more dynamic adaptation of the game to the different case studies. This, for e.g., would allow for the quick introduction of the several game ideas users had in chapter 4.4, and test them in their provided game play. This led to the implementation of an online information system in three stages: at a first stage of development, challenges should be put into the system and synchronised with the mobile game application; at a second stage, users should be able to introduce these challenges themselves; at third stage, an administrator should double check the content proposed by users in its appropriateness (e.g. foul language, or unsafe locations), or introduce challenges him/herself. The first stage is a design choice that enabled the referred loose-coupling between the content of the game (the challenges) and the game world in itself. The second stage goes in line with the essential architectural module of participation from chapter 5, meant to give players a contributing role in the game that contributes to a recurrent game play over time. The third stage goes in line with the essential architectural module of administration from chapter 5, meant to enable centralised coordination and upkeeping of the entire game, the content of the game, the players, and their statistics, all the while proposing challenges as well.

6.4.5. IMPLEMENTATION OF THE ARCHITECTURE AND THE KEY COMPONENTS

This subsection describes how the SotS implements the modular software architecture proposed in chapter 5, and how the game implements its key components. By implementing all of the services of the modular software architecture (figure 5.3), it was possible to build a location-based game that is capable of promoting social interaction in public space, that implements the key components. Figure 6.16 illustrates the outcome of this implementation, showing the game application and the game portal on the left, and detailing how the services were implemented more specifically on the right.

The mobile computing device in figure 6.16 contains the **Augmentation**, **Navigation** and **Interaction** key components, and requires support from the services indicated in the same figure. The **Augmentation** and **Navigation** key components are supported by the *Positioning Service*, that provides a 3D map and 3D buildings. The game sends the GPS coordinate of a smartphone to this service, that, in turn, returns a stream of map tiles (and their topology), covering hundreds of metres in every direction of a player's location. This is used by the game to position a player and the challenges in the real environment, for game play based on true location. The **Interaction** key component is implemented in the game application and is supported by the *State Progression Service*. The GUI the game provides centres on the 3D representation of a player's environment with touch and multi-finger map manipulation using menus. The *State Progression Service* presents the challenges, and supports indirect interaction between players by providing the functionality needed for players to attach pictures taken during a challenge, to view other players' pictures, and to vote for them.

The **State Progression** key component is supported by *State Progression Service*. The SotS provides players a personal area in the game that contains their game statistics (points earned, challenges solved and their different types, challenges players were the first to solve, and the number of challenges created by a player online), and a set of leader boards (one for the players that met the highest number of other players by scanning QR codes; and the other for the teams of players, ranking the teams that solved the highest number of multiplayer challenges).

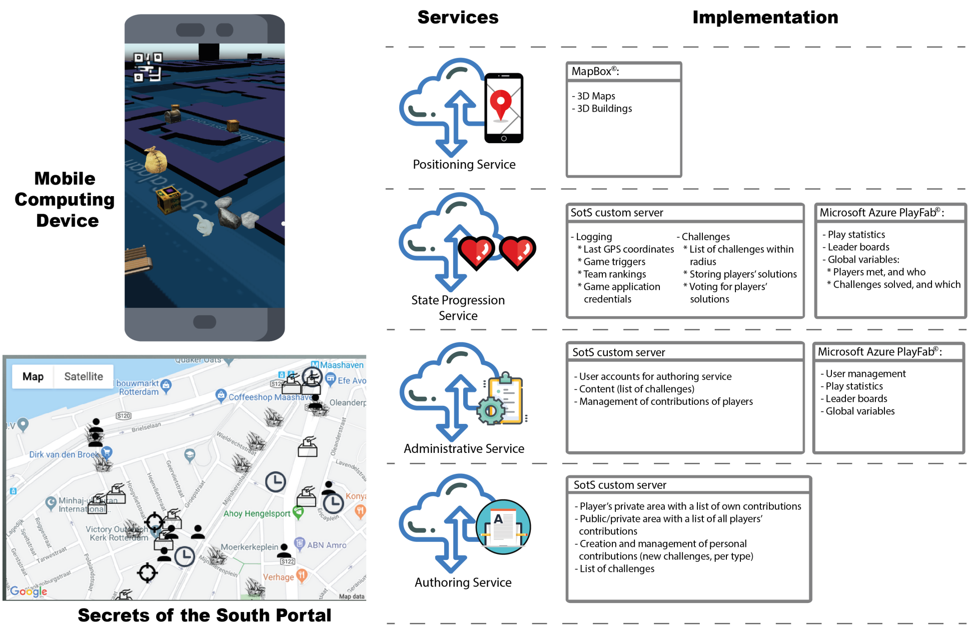


Figure 6.16: Implementation of the modular software architecture in the Secrets of the South[7].

The SotS game portal implements the **Participation** and **Administration** key components as follows. The Participation key component is implemented by the *Authoring Service*. Players can access the online game portal, which, after the login, provides a private area. There they have access to a world map and a list of challenges. Both the map and the list show all of the playable challenges in the game. The map enables users to acquire a general perception of where the challenges are located (where they can be played). The list of challenges also indicates which challenges were created by the logged player. The online *Authoring Service* also enables players to propose an unlimited number of challenges, edit and delete them. Lastly, the **Administration** key component is implemented by the *Administrative Service*. A system of credentials is vital to game management and is managed in one of 3 ways: by 1) the online system (or at the database level), 2) the PlayFab service, and/or 3)

[7]Mapbox refers to Mapbox maps and location services provided by https://www.mapbox.com/; Microsoft Azure Playfab refers to a complete backend platform for online games (https://playfab.com/); SotS custom server[4] was implemented with MeteorJS fullstack development framework together with MongoDB for data storage, both deployed at a virtual server provided by TU Delft ICT services.

the mobile application. In 1), a user with specific rights (administrator) can not only participate in content creation, he/she can also (in)validate other users' challenges (only validated challenges appear in the game application). An administrator can create/revoke challenges and user accounts. In 2), an administrator can modify leader boards, global variables and statistics. Lastly, in 3) the mobile application supports different types of user accounts (regular players, evaluators of Multiplayer challenges, and administrators). During game play, administrators can manage the credentials of players by scanning their in-game QR codes (either elevate, or demote). This changes the options offered in the menus of the game, to support different dynamics of play while playing (e.g. a workshop, where the evaluators of teams are not known beforehand).

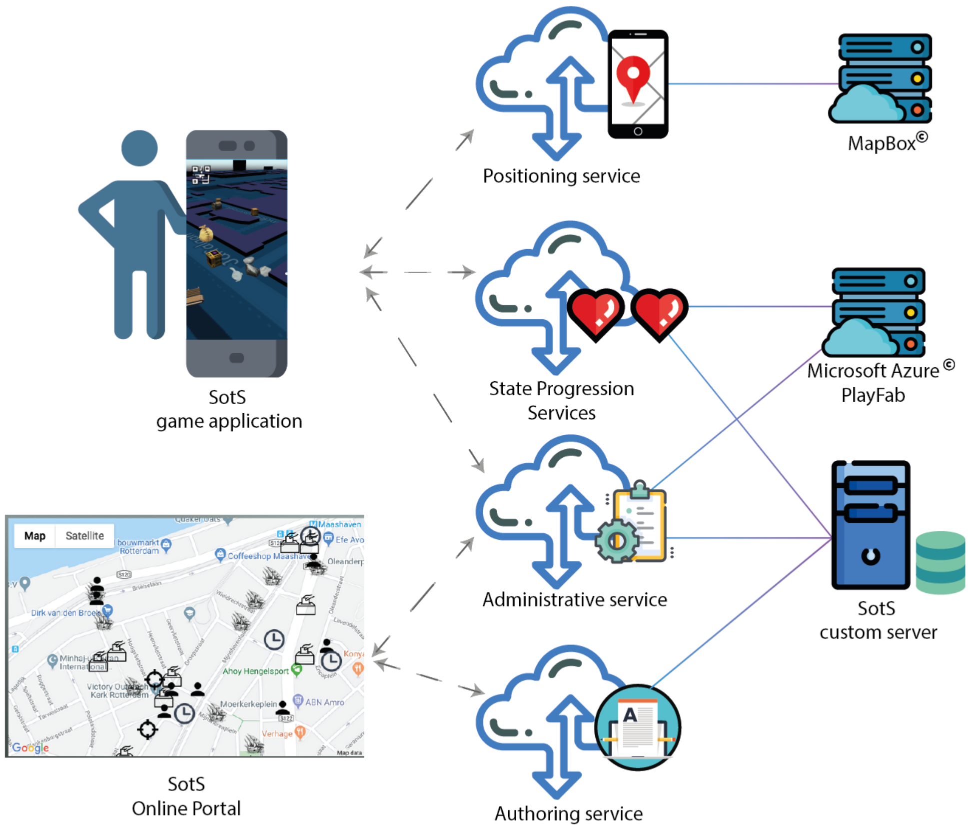


Figure 6.17: Implemented interaction between components in the systems architecture of the Secrets of the South.

The overall interaction across all the components of the system is depicted in figure 6.17. It illustrates how the overall system's architecture is implemented with regard to both the servers and the 3rd party services used, and also describes the way that the SotS mobile game and portal interact with the services implemented. The implementation of the SotS game application that runs on a mobile computing device communicates directly with the *Positioning*, *State Progression*, and *Administrative* services to render the map and position a player according to the location of the device and the information provided by the *Positioning Service* (**Navigation** and **Augmentation** key components). It also enables the game to provide a gameplay experience aiming at interaction with the game environment and people (**Interaction**) that is supported by the *State Progression Service* (**State Progression**). Finally, some administrative tasks can be performed by players with specific permissions due to the link with the *Administrative Service* (**Administration**), e.g. player management. The SotS game portal communicates directly with the *Administrative Service* for the same purpose and all the other administrative tasks afforded by the game. The *Administrative Service* also makes it possible for players to participate with their own challenges, through the connection to the *Authoring Service* (**Participation**).

Note that all services are essential to gameplay. Without the *Positioning Service*, the game would not be able to represent the environment of the player; the absence of *Administrative Service* would make the game incapable of adapting to the dynamic behaviour of players, rendering it inconsistent and useless; not having an *Authoring Service* would make players incapable of adapting the content offered by the game to the different types of social interaction they desire; and not having *State Progression Service* would mean not having a functional game.

6.4.6. SUMMARY

The Secrets of the South game design, proposed in this chapter, is based on the learnings of previous chapters, which reflect not only the requirements users have, but also lessons learned from the literature on how such LBGs should be put together. This game design, fully explained in this chapter, is turned into an actual prototype, and the source code is published online. This allows other researchers and game designers/developers to verify the implementation of the prototype done, but also appropriate the project, build on it, or even modify it for different purposes other than fostering social interaction in public space. For full account on 1) the technology used, 2) the functional requirements and how these were implemented in the game, and 3) the run-time execution of the game and its entire behaviour through activity diagrams, please see appendix D. Next chapter details the testing and validation of this prototype.

7

Playing the Game

One day, you might look up and see me playing the game at 50.
Don't laugh. Never say never, because limits, like fears, are often just an illusion.

Michael Jordan

This chapter aims at validating the SotS game prototype presented in the previous chapter, which is created based on 1) the users' choices for gaming activities, 2) the gameplay they provide, and 3) the system's architecture that such a game should have for the fostering of interaction in the mentioned conditions. Two research questions are posed in this chapter to evaluate: 1) **if and when meaningful social interaction occurred during game play and how, with which impact**, and 2) **the design choices/features that contributed to (the experience of) meaningful social interaction**. Recalling the definition used in this work for meaningfulness (chapter 2.7), meaningful social interaction is an overall enjoyable experience for a player, and enjoyable or neutral for individuals involved in the gameplay. The SotS prototype is tested in this case study with the same adolescents producing the 56 specific game ideas from chapter 4.4, which are adapted to, and offered by, the game (the challenges adapted to the game, from the original set of 56 game ideas, are shown in Appendix C). By researching these 2 research questions, this chapter evaluates the SotS game prototype in its ability to invite players into a game play that can lead to meaningful social interaction in their own neighbourhood. In the event such goal can be achieve, this chapter also seeks to offer design guidelines that can support practitioners in the creation of such games in the future.

This chapter is based on the published article: X. Fonseca, G. Slingerland, S. Lukosch, and F. Brazier, *Designing for Meaningful Social Interaction in Digital Serious Games*, Entertainment Computing, doi: https://doi.org/10.1016/j.entcom.2020.100385, 2020.

7.1. RESEARCH DESIGN FOR PLAY TESTING

Three play test sessions were organised with the same primary school (and adolescents) involved in the design of the specific challenges reported in the case study of chapter 4.4, in the district of Tarwewijk, to: 1) evaluate if social interaction occurs, how it occurs, and understand its impact on the players, and 2) evaluate the SotS game in its capacity to provide opportunities for meaningful social interaction.

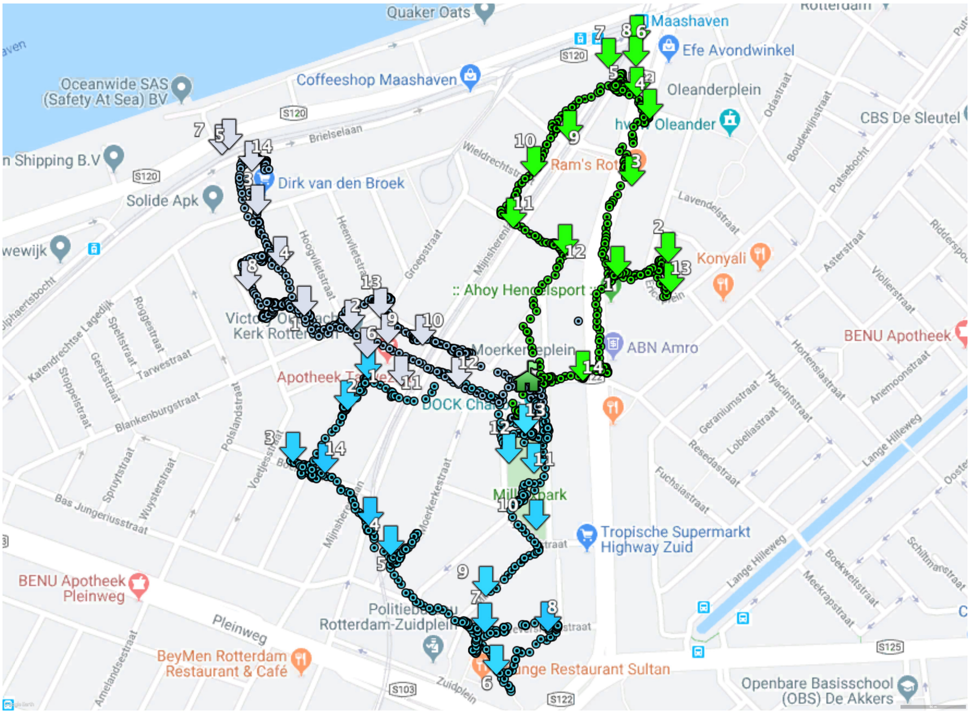


Figure 7.1: Route 1 (lime green), route 2 (light grey), and route 3 (light blue). Icon with the green house marks the school: the start and end point. Arrows mark the location of the 14 challenges per route, the dots the expected path.

Figure 7.1 depicts the location of the school, the three routes (colour coded), and the exact location of all of the challenges included in SotS for the adolescents to play. Each route includes 14 challenges: 2 challenges per challenge type, where possible unique to the route (e.g. a particular point of interest). Only a few challenges overlap across different routes. During play testing each adolescent walks one route. The 14 challenges per route are described in detail in Appendix C.

7.1.1. PROCEDURE

Three play test sessions were organised, one for each class, two in the morning of Day 1, and one in the afternoon of Day 2 (not sequential):

- Day 1, 09:00-10:45, class 7B;

- Day 1, 10:30-12:15, class 7A;
- Day 2, 13:00-14:45, class 8;

Each play testing session entailed:

- 10 to 15 min. of initial classroom instructions, forming of groups, and phone distribution;
- 1 hour of play testing;
- 30 minutes of debriefing with adolescents in class (overall discussion on the game play);

In total 64 adolescents between the ages of 10 and 11 participated in the play testing sessions: 22 in the first session, 20 in the second and 22 in the third.

- The in-class instructions focused on : 1) the 1 hour to play, 2) that there are multiple challenges located in the neighbourhood, 3) reminding them how to use the game (they can use the game to see which challenges are the closest to them, then select one challenge and walk to its location to play), 4) that if they do not want to play a challenge they can choose another one, and 5) that they can only play the challenges on that route they are assigned;
- After the initial instructions, teacher-defined groups of 5-6 adolescents with 1-2 facilitators were formed and each group assigned a route (by the researchers). The role of the facilitators (teachers, researchers, assistants) was to oversee the adolescents' safety, to provide guidance when needed, and to collect data through observation. Each pair of adolescents was handed identical mobile phones on which the game and the challenges were pre-installed[1];

Figure 7.2 shows pictures of adolescents working together to solve challenges, conversing with strangers, and competing against each other to tackle the challenges. The weather was far from optimal for the first 2 groups (cold and windy). The third session was rescheduled to a day with better weather conditions. The distribution of the groups per route, and the number of adolescents per route, are depicted in table 7.1.

[1] 12 smartphones were used in the session 1, 10 in session 2, and 12 in session 3, all of the same brand, model with the same specifications.

Session 1			Session 2			Session 3		
Group 7B (22 adolescents)			Group 8 (22 adolescents)			Group 7A (20 adolescents)		
Groups	Route	Players	Groups	Route	Players	Groups	Route	Players
1	1	6	1	1	6	6	3	6
2	2	6	2	2	6	7	3	6
3	3	6	3	2	6	8	2	4
4	1	4	4	3	4	9	1	4

Table 7.1: Division of adolescents per play test session, groups and routes.

After the game play, the groups returned to school for a debriefing session in the classroom. The following questions were asked by a researcher in a semi-structured way:

1. Who liked the game?
2. What was fun about it? What did you like? What did you not like?
3. Which challenges were the best? Why?
4. Who has played challenges where you had to work together? Was that nice? Why?
5. Who has played challenges where you had to play against each other? Was that nice? Why?
6. Has anyone met a new person while playing? For example, someone on the street? And how was that?

Questions 1, 2, and 3 address their experience of the game play, questions 4, 5, and 6 the quality and impact of social interaction.

7.1.2. DATA COLLECTION

Different types of data were collected during gameplay, both qualitative and quantitative. Observations of the facilitators and (recordings and transcriptions of) the debriefing sessions are qualitative data, whereas the data collected from the game and the game server (GPS locations, answers given by players, photos taken by players as part of a challenge, and data from the server of the game on which challenges were opened and solved) are quantitative. In addition, photos were taken by players during gameplay (independent of the task at hand) for illustrative purposes. The answers to the challenges themselves, and the photos taken by players, were collected and used when appropriate for a better understanding of the quality of the game play. GPS data was collected with the purpose of plotting the locations of players on the map, and analysing potential overlaps/interactions over time across players (this did not reveal anything meaningful). Adolescents were interviewed during the debriefing sessions as a whole class and by the same research interviewer (the teachers present in these debriefing sessions varied per class).

Figure 7.2: Examples of the game play of SotS, by different groups of adolescents: adolescents interviewing strangers (top left), solving a challenge together (top right), competing against each other (bottom left), and playing together (bottom right).

7.1.3. Procedure for data analysis

Transcriptions of the audio recordings were translated from Dutch to English by Dutch research staff, as were the observations of the facilitators. This data was sorted into nine content areas: quotes and observations were separated for each challenge type (Athlete, Inventor, Detective, Explorer, Hunter, Artist, Volunteer), creating seven content areas. One content area contained quotes from the debriefing sessions that did not concern a specific challenge. The last content area was sorted from the overall observations of the facilitators. Two independent researchers analysed the above content areas using qualitative content analysis (Graneheim and Lundman, 2004) to better understand the meaning of data in relation to the two research questions this study addresses: 1) if and when meaningful social interaction occurred during game play and how, with which impact, and 2) the design choices/features that contributed to (the experience of) meaningful social interaction. To address these research questions, the researchers started their analysis of the content areas from three more straightforward questions: 1) Was there social interaction, 2) How meaningful (positive) was social interaction to the adolescents, and 3) How did the game support social interaction (how was it played). The first two questions link to the first research question and the last question links to the second one.

This first step of the analysis required the two researchers to independently interpret all the quotes and observations by assigning them to one of the three sub-questions and noting down the meaning of the data excerpt as a code (Saldaña, 2015). Each researcher produced their own list of codes and grouped these into a set of clustered codes that was big enough to show the variety and richness in the data, and at the same time manageable to discuss amongst the two researchers. These two sets of clustered codes were compared and discussed, resulting in a new framework of codes that was used to reclassify the original data set (Axial coding (Saldaña, 2015)) to address the two research questions. Differences in coding were discussed à-posteriori with a third researcher, also involved in the game play test sessions. The final coding framework contained codes to describe the general play experience of adolescents as well as specific experiences for each challenge type. The columns in figure 7.3 represent the results achieved with the final coding framework. The analysis of the quantitative data was mainly arithmetic: the percentages of the overall number of challenges that were opened and solved and the percentages for each of the challenge types were calculated.

7.2. RESULTS

This section analyses the quantitative and qualitative data to address the two research questions.

7.2.1. QUANTITATIVE DATA

The quantitative data indicates: 1) the number of challenges players opened (how many challenges players engaged with), 2) the number of opened challenges actually solved, and 3) the relation between opened and solved for each of the challenge types, as depicted in table 7.2. Columns **C.** refer to a specific challenge that was played in all sessions (e.g. C. 1.5 refers to challenge 5 that was played in session 1). Sessions 1 and 2 had 12 players each, and session 3 had 10 players.

7

As the number of players differed per session, a normalised average based on the min-max normalisation method is used, for the purpose of comparison of the challenges opened and solved across all the sessions. Equations 7.1 and 7.2 are used to calculate the overall percentage of challenges opened and solved for each type of challenge: per each value, equation 7.1 normalises the range of the value into [0-1], and is then added to equation 7.2 for the arithmetic mean. The *min (x)* is zero for all sessions, because a challenge could have been played by any adolescent; however, *max (x)* varies per session (it equals 12 for values from sessions 1 and 2, and 10 for those from session 3).

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)} \tag{7.1}$$

$$AM = \frac{1}{n}\sum_{i=1}^{n} x' \times 100 \tag{7.2}$$

Table 7.2 shows the normalised average number of challenges opened by players, and challenges solved by players, per type of challenge, after the application of the equations 7.1 and 7.2. These averages show that more than half of the challenges were opened for each of the challenge types, and that, for most types of challenges, the participants solved them. Less than 10% of the challenges opened were not solved for the challenge types Artist (≈3%), Athlete (≈6%), Detective (≈9%), and Volunteer (≈3%) (based on the difference in normalised averages for these types). This number was higher for the types Explorer (≈21%), Inventor (≈14%), and Hunter (≈31%). Overall, of the 42 challenges (14 per route) ≈82% were opened, and ≈70% were solved.

	Artist			**Athlete**			**Detective**			**Explorer**		
	C.	Op.	Sol.	C.	Op.	Sol.	C.	Op.	Sol.	C.	Op.	Sol.
	1.5	12	12	1.2	11	11	1.4	12	11	1.10	12	9
	1.9	12	10	1.13	10	7	1.11	11	10	1.12	6	5
	2.3	12	12	2.9	9	9	2.1	11	11	2.2	10	0
	2.5	11	11	2.10	12	12	2.7	10	8	2.12	11	11
	3.1	10	10	3.10	8	7	3.4	7	5	3.6	10	10
	3.9	9	9	3.11	9	9	3.5	10	10	3.8	10	9
Sum (max 68)		**66**	**64**		**59**	**55**		**61**	**55**		**59**	**44**
Avg. (%)	**Op.:**	**≈ 97%**		**Op.:**	**≈ 87%**		**Op.:**	**≈ 89%**		**Op.:**	**≈ 88%**	
	Sol.:	**≈ 94%**		**Sol.:**	**≈ 81%**		**Sol.:**	**≈ 81%**		**Sol.:**	**≈ 66%**	

	Hunter			**Inventor**			**Volunteer**		
	C.	O.	Sol.	C.	O.	Sol.	C.	Op.	Sol.
	1.3	8	5	1.7	8	3	1.1	10	8
	1.6	10	7	1.8	9	5	1.14	11	11
	2.11	8	7	2.4	4	3	2.6	6	6
	2.13	11	8	2.8	2	2	2.14	12	12
	3.2	10	0	3.3	5	5	3.12	4	4
	3.13	9	9	3.13	9	9	3.14	9	9
Sum (max 68)		**56**	**36**		**37**	**27**		**52**	**50**
Avg. (%)	**Op.:**	**≈ 83%**		**Op.:**	**≈ 55%**		**Op.:**	**≈ 76%**	
	Sol.:	**≈ 52%**		**Sol.:**	**≈ 41%**		**Sol.:**	**≈ 73%**	

Table 7.2: Distribution of the interaction of players with each challenge, organised per type of challenge: challenge (**C.**) opened (**Op.**) and solved (**Sol.**) by players. The normalised average (**Avg.**) of opened and solved challenges is shown per type of challenge (in percentage).

7.2.2. QUALITATIVE DATA

As each type of challenge is defined by the specific dynamics of play and interaction entailed, expectations that the researchers had for the interaction during gameplay, and the interaction that actually occurred per type of challenge are compared. The following section presents and analyses the results for both the general gameplay, and type-specific gameplay.

GENERAL GAMEPLAY

Both coders identified 3 to 4 times more statements on positive play experience and positive interactions than negative:

- "You have multiple assignments... and you walk around in groups through the neighbourhood. You do things and see things that you have not done before or have seen before" (adolescent 3, session 1).
- [What did you like?] "Helping people. For example, lifting their grocery bags." (adolescent 2, session 2).

Adolescents reported that the challenges they enjoyed most were the ones with physical exertion (e.g. running against one another), and those where they had to engage with strangers, even more than in-group interaction:

- "[What did you like?] Ask people at the square what you can do there.", [and why was that fun to do?], "You get to know more reasons to go to the square." (adolescent 6, session 2).
- "We could talk about things together. For example, the rap. [another adolescent] and I had to think of something together. And, for example, another group had also thought of something together. And the teacher also came up with two sentences.", [So, everyone helped?], "Yes." (adolescent 18, session 1).

These outcomes are in line with the observations made by the facilitators: most observations are positive, a few negative. Negative experience primarily related to external play conditions such as the extreme cold weather, or the location of certain challenges (e.g. stores) that were not young adolescent friendly. Statements regarding the perceived unwillingness of people to interact, or their inability to speak the Dutch language, provided an opportunity for reflection during the debriefing session together with their teachers and workshop facilitator:

- "A few people were arrogant.", [Why was that?], "For example, ... [another adolescent] went to ask another women, he asked something and that woman first laughed and then she said no.", [that is not nice], "Especially because she thought it was funny." (adolescent 19, session 3).
- "There was a lady who could only speak English and I didn't understand it. Because she just said a few words. So I looked at her like 'huh?'. But ... my teammate, did talk to her so I understood it." (adolescent 19, session 1).

Adolescents were not aware of such reality in their neighbourhood (e.g. that people do not speak their language), and such experiences, even though initially perceived as frustrating and negative, actually turned out to be a positive learning opportunity for the adolescents.

TYPE-SPECIFIC GAMEPLAY

Each challenge has a type, and the researchers had expectations on the type of interaction that each type of challenge could/would foster. Our results compare these expectations with the actual outcomes of the game play, and are summarised in figure 7.3:

Artist: The expectation was that in-group collaboration, either with active or passive participation in the performance would be appreciated by most. No interaction with strangers was expected. Results show that, for some adolescents, it was really hard to do these challenges and finish them (e.g. to rap), whilst others wanted to do these same challenges so badly that they started running towards the location as soon as they found them in the game. It was experienced by some to be easy and by some to be hard (50% each). Nonetheless, adolescents agreed that they really enjoyed these challenges: they worked together in collaboration, had in-group interaction (which gave them a nice play experience), with no interaction with strangers (as expected).

Athlete: This type of challenge is designed for physical performance (e.g. seeing who is the fastest in climbing a tree). The expectation was that both non-verbal interaction (e.g. touch, body language, posture, facial expression, gestures, or eye contact), and verbal communication (e.g. speech on behaviour instigation), would be observed/perceived across play dynamics of cooperation and competition in-group. Results show general competition, but with substantial collaboration emerging. Adolescents collaborated to solve the challenges, by e.g. agreeing on the rules, keeping track of time and scores, and encouraging each other while doing the parkour. Interaction was primarily in-group (as expected), the challenges were relatively easy to solve, and the number of remarks on how hard they were to do did not seem to show an effect on their play experience. Adolescents liked these challenges, had a positive play experience, and their comments related to the tennis ball (which was too small) and the cold weather.

Detective: The expectations for this type were for adolescents to occasionally ask people on the streets to provide them with the information they needed, thus mild engagement with strangers, and most engagement within the group. These interactions were expected to be based on verbal communication only. Results are in line with these expectations: collaboration and interaction within the group and with strangers are both observed. There was also interaction with the physical space surrounding them (e.g. with the flags they were trying to identify to retrieve the answer to the question, or when looking for a placard with the answer). However, the adolescents did not enjoy this challenge type as much as others: 50% liked these challenges, 50% did not (some of the questions were not relevant to them, or they did not care much about them). These challenges were successful in motivating adolescents to work together and collaborate in interacting with strangers, the environment, and in-group, but they did not, in general, lead to a positive play experience. The interaction they had with strangers was considered to be neither positive nor negative, and thus neutral to the adolescents.

Explorer: The expectations for this type were the same as for the type Detective. Results show that, unlike the type Detective, these challenges were relatively easier for them to solve, and that they were enjoyed more by the adolescents. Comparable to the type Detective, these challenges lead to collaboration, substantial interaction both in-group and with strangers, and mild interaction with their physical environment. In comparison, adolescents also express and show positive interactions with strangers.

Hunter: As these challenges can be solved with a QR code, our expectations were that little interaction with strangers was to be seen, and mild engagement/ collaboration within the group (verbal communication, and joint physical performance). Results show that adolescents liked the challenges, collaborated, and had positive social interaction with each other and strangers. They experienced these challenges to be more often easier than harder for them (though not that easy, they struggled as well). This type of challenge can also lead to competition. The expectations were to observe mild engagement, but this type was one of the best for engagement in interaction with everyone. They engaged in-group, with strangers, and with the physical environment, which resulted in a very positive play experience.

Inventor: For this type of challenge, the expectations were to observe individual behaviour (no interaction), and mild in-group interaction only, with possible cooperation in the creative process. Results show that adolescents liked the challenges, with minimum collaboration and no competition, some in-group interaction, and individual play (no interaction). Adolescents thought the challenges of this type were difficult to play, especially the creative exercises (e.g. coming up with ideas), but these provided a positive play experience to them. Although the challenges were difficult for them to solve, they still enjoyed them.

Volunteer: Researchers expected to observe potential collaboration in-group, in doing the same volunteering tasks (verbal interaction, perhaps with some physical coordination) and some verbal interaction with strangers. The results show that adolescents liked to play these challenges and had a positive play experience. They had equal interaction in-group and with strangers, and collaborated, which falls exactly in line with the expectations.

	Expected Outcome	**Actual Outcome**
Artist	• Collaboration in-group. • No interaction with strangers.	• Collaboration in-group. • No interaction with strangers. • Hard to solve, but deeply desired. Fun to do.
Athlete	• Physical performance with verbal and non-verbal communication. • Collaboration and competition in-group.	• Physical performance with verbal and non-verbal communication. • Collaboration and competition in-group. • More competition than collaboration. • Adolescents liked and had positive game play. • Relatively easy to solve.

Table 7.3 (continued)

Detective	• Mild engagement with strangers. • Most interaction in-group.	• Mild engagement with strangers. • Most interaction in-group. • Strong collaboration. Very hard to solve. • Interaction with the environment. • 50% of adolescents liked this type, 50% did not. • Negative play experience. • Neutral interaction with strangers.
Explorer	• Most interaction in-group. • Mild engagement with strangers.	• Substantial interaction in-group. • Substantial interaction with strangers. • Mild interaction with the environment. • Easy to solve, liked by adolescents. • Collaboration. • Positive interactions with strangers.
Hunter	• Rare to no engagement with strangers. • Mild engagement in-group. • Collaboration. • Physical performance with verbal + non-verbal communication.	• Strong collaboration. Can lead to competition. • Strong engagement in-group. • Strong engagement with strangers. • Strong engagement with the environment. • Very positive play experience, liked by adolescents. • Positive interactions overall. • Easier to solve, but with relative difficulty.
Inventor	• Individual game play. • Mild in-group interaction. • Possible collaboration.	• Minimum collaboration. • Individual game play. • Mild in-group interaction. • No competition. • Liked by adolescents. • Hard to solve, but positive play experience.
Volunteer	• Mild interaction with strangers. • Interaction in-group. • Possible collaboration. • Verbal communication with potential physical coordination.	• Mild interaction with strangers. • Mild interaction in-group. • Collaboration. • Verbal communication. • Liked by adolescents. • Positive play experience.

Table 7.3: Summarisation of findings per type of challenge, with regard to the outcomes. Expectations that were met are marked in lavender.

ANALYSIS OF RESULTS

Figure 7.3 summarises the qualitative data analysis done. Figure 7.4 summarises the quantitative data analysis on the percentage of the challenges that players opened, and, out of which, solved. The columns in figure 7.3 represent the results achieved with the final coding framework, and are used to answer the research questions of this study: exchanges (individual play, in-group interaction, interaction with strangers, interaction with environment), appreciation of players for the challenges, positive gameplay experience, easiness in solving the challenge, levels of collaboration, and how meaningful interaction was.

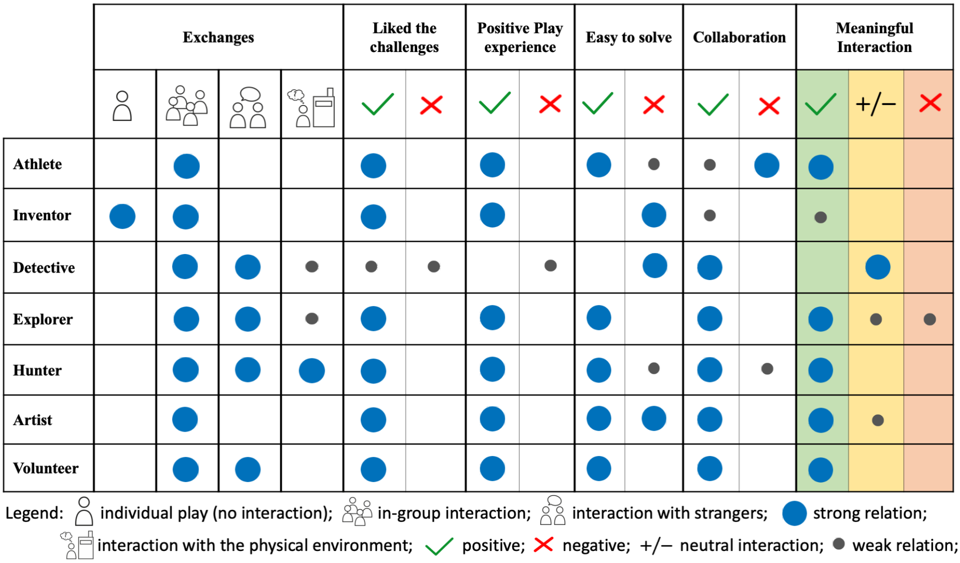


Figure 7.3: Summary of the game play per type of challenge: type of interaction fostered, how positive it was to players, and the dynamics and impact of the game play on players.

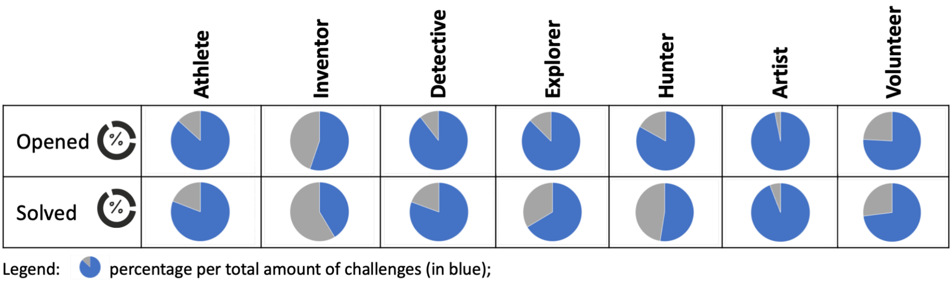


Figure 7.4: Engagement with challenge type.

The first column on the left of figure 7.3 ("Exchanges") addresses if there was interaction, and examples of the coding scheme used are "collaboration in group", "collaboration in pairs", "help each other proceed", "talking to strangers", "meeting new people", and "interesting places". The 4 columns in the middle ("Liked the Challenges", "Positive Play Experience", "Easy to Solve", and "Collaboration") address how the game supported social interaction. These categories were assessed based on coding schemes such as "ask for more challenges", "play one challenge multiple times", "urge to finish all challenges", and "having fun as a group". The last column on the right ("Meaningful Interaction") addresses the meaningfulness of the interaction players had. The coding scheme used for this category consisted on clusters of codes for positive, neutral, and negative interaction. The positive cluster of codes consisted of codes such as "helping others", "learn about neighbourhood practices", "return to fun new places", "playful interaction with strangers", "being recognised", and "getting to know people from the neighbourhood". Neutral codes were for example "meeting new people", "overcoming language barriers", "unexpected response", "persistence", and "surprised". Lastly, the negative codes were for example "being ignored", "embarrassing", "not returning to discovered places", "not interested in challenge", "being laughed at by strangers", and "scary places".

These columns, together with figure 7.4, guide the answering of the research questions in the following subsections.

A. Social interaction that is meaningful

The first research question of this study asks: if and when meaningful social interaction occurred during game play and how, with which impact?

Regarding the first part of the question, social interaction occurred . In-group interaction was observed in all types of challenges, between pairs of adolescents holding smartphones, and in-group interaction where adolescents worked together (not just in pairs). In 4 of the 7 types of challenges, the adolescents interacted intensively with strangers. In 3 of the 7 types of challenges, the adolescents interacted with the physical environment as well, that also lead to other types of interaction. In some types of challenges, the adolescents had fun but did not really interact (e.g. the type Inventor), whereas in others they interacted but did not have fun (e.g. the type Detective).

Regarding the second part of the question on how interaction occurred, the adolescents collaborated in all challenge types, and the level of collaboration was intense for most. Competition occurred, but this competition mainly related to the improvement of an adolescent's own performance (rarely against other adolescents). The adolescents supported each other in difficult tasks, and either instigated other adolescents to go talk to strangers, or the whole group was involved. The adolescents also approached strangers as a group: they wanted to interview them together, get to know what was possible to do in their neighbourhood, and help other neighbours for free.

Regarding the third part of the question on the impact of interactions on the players, these interactions mostly had a positive effect. The adolescents wanted to engage with as many strangers as possible, they were observed to be kind and polite, asked many things, and, even when they were not successful at carrying someone's bag, they still felt great in trying. In some other cases in which some adolescents felt rejected (the neutral experiences described above in section 7.2.2), they sought to find a solution to the problems they encountered, by trying, for example, to switch from Dutch to English. Very few statements were classified as negative, and these were associated with people being perceived by the adolescents to be arrogant.

The definition of *meaningfulness* in the context of social interaction defined above in section 2.8.2 is that of *an overall enjoyable experience for a player, and enjoyable or neutral for individuals involved in the gameplay*. On the basis of this definition the interaction that emerged within the challenge types Athlete, Inventor, Explorer, Hunter, Artist, and Volunteer can be classified as more meaningful than not meaningful. The adolescents interacted heavily in-group (which sometimes also included their teacher), and they had fun doing so for the most part. The adolescents also interacted substantially with strangers in the challenges of the types Detective, Explorer, Hunter, and Volunteer, and, with the exception of the type Detective, the adolescents enjoyed engaging with people on the street and learning all sorts of things from them. The challenge type Detective was successful at fostering social interaction with strangers, but was not experienced by the adolescents to be meaningful.

This, together with the success of the other types of challenges, can be used to reflect on the appropriateness of the content provided by the game framework. Each type of challenge was designed for different game play, to appeal to a more varied number of adolescents, and to explore the neighbourhood in different ways. Most challenge designs were experienced to be interesting and relevant for the adolescents, providing a positive play experience, with an exception being the challenges of type Detective. Worth noting is that a challenge can be designed in a way that is appealing to the target group, and yet provide the player with non-meaningful social interaction (e.g. the types Explorer and Artist). This reflects the difficulty to design for non-deterministic scenarios such as social encounters with other people, and requires further research.

B. The game creates opportunities for social interaction

The second question this study addresses relates to the design choices/features that contributed to (the experience of) meaningful social interaction (how well the game worked). The game supports co-located experiences in the neighbourhood through interaction with the physical and social environment. There was not one adolescent that did not like any challenge at all. Anecdotally, difficult challenges provided an opportunity for adolescents to find creative solutions such as involving their teachers in their task (e.g. contributing to make a rap song): not the interaction most likely envisioned by the adolescents when they designed this challenge, but an emergent form of social interaction.

Analysis of the specific types of challenges, and the expectations of the researchers versus the reality of how the game play shows the following: *Detective*, *Explorer*, and *Hunter* are very comparable in terms of interaction (not in terms of easiness nor in terms of appreciation). In terms of appreciation, *Hunter* and *Explorer* are similar: adolescents experienced them very positively, and perceived them as relatively easy. *Hunter* can lead to competition, which is different from *Detective* and *Explorer*. *Hunter* was easier than *Detective*, but it was still sometimes challenging to solve. *Detective* was hard, *Explorer* was easy, and *Hunter* was in between. Both *Detective* and *Artist* were hard for the adolescents, but they liked *Artist*, and did not like *Detective* as much. Adolescents prefer to be explorers than detectives: it could be due to the questions asked, or due to the nature of the activity (this distinction cannot be made). They seem to prefer challenges where they explore their environment (e.g. which restaurants are in ...) than trying to find a specific answer in the environment (e.g. how old the school is). Alternatively, they may prefer *Explorer* over *Detective* because the challenges were easier for them to do. The design choice to include different types of (user-defined) challenges with varying degrees of difficulty and types of interaction has shown to be effective.

The SotS game framework worked in creating opportunities for players to socially interact with the neighbourhood, their friends, teachers, and people passing by. Players could navigate the map offered by the game, and find the challenges to be solved. The challenges require different tasks to be solved, exploit the topology of the neighbourhood and its points of interest, and promote the game play to evolve on these spots. These opportunities could only be created with a game that is aware of the location of players, and include people passing by in the game as well. To this end, smartphones with GPS sensors, and with tactile screens capable of providing guidance to players, proved to be efficient design choices for meaningful social interaction. The navigation and orientation offered by the game was challenging to many adolescents, particularly the younger ones (from classes 7A and 7B), and future games for this purpose and target group should assist adolescents even further in navigating the map.

7.3. DISCUSSION AND LIMITATIONS

The results of the design and evaluation of the SotS game, designed for meaningful social interaction as discussed above, shed light on the effect of specific design choices in the context of gameplay with adolescents in Rotterdam. This section summarises the findings of this study as design recommendations, and relates these recommendations to the generic design guidelines described in chapter 6.

7.3.1. DESIGN RECOMMENDATIONS

The recommendations, presented below in table 7.4, are not at the level of the design choices made for the actual implementation of the game play, as the specific design requirements and game dynamics (chapter 4.1), but refer to the design choices made during game concept definition. These recommendations provide a basis for future designs of serious games for meaningful social interaction, based on the experience reported in this chapter and in the literature.

7

	Guideline	Reasoning
1.	**Game play should be location-aware.**	Location-based gameplay in one's own neighbourhood, with the people in it, and real-world points of interest has shown to be successful.
2.	**The game play should be augmented and mediated.**	Display technology (such as the screen of the smartphone) supporting navigation of the environment throughout the game has shown to affect willingness to play and overall play experience.
3.	**Challenges must align with their physical location.**	Alignment of a challenge with its physical location has shown to be essential (e.g. guarantee the store to which a challenge refers is actually open).
4.	**Challenges must be tailored to the specific social context of the game play.**	Alignment of a challenge with its social context has shown to be essential (e.g. taking language barriers, accessibility into account).

Table 7.4 (continued)

5.	**Challenge content needs to be relevant for the adolescents and build on their understanding of the world.**	Challenges designed by the target group relate to their own world of experience. (The world of adults, for example, is very different from that of adolescents).
6.	**Challenges that are played in a group trigger more social interaction than single player ones.**	Having a group work together to engage in interaction with others in the neighbourhood has shown to be more effective (with regard to experience) than when approached by individual players.
7.	**Provide different types of challenges, to appeal to different scenarios, difficulties, and players.**	Players are not all the same, and the game should provide with enough variety to account for that.
8.	**Include challenges with physical exertion and involvement with other people (players and non-players).**	Challenges requiring (physical) interaction with the physical and social environment have shown to be the most motivating.

For meaningful social interaction	
9.	**Of all types (in-group, with strangers, and with the environment):** challenges of type *Hunter* are recommended.
10.	**Within the group and with strangers:** *Hunter* and *Explorer* challenges are recommended the most. *Detective* challenges are recommended only if adolescents relate to (or are fond of) the content of the challenge.
11.	**Primarily within the group:** challenges of type *Athlete* are recommended the most, followed by *Hunter* and *Volunteer*.

Table 7.4: Design guidelines for location-based games fostering meaningful social interaction in public space.

Laamarti et al's guidelines to "provide guidance to players" and to make "use of the display of the smartphone" (Laamarti et al., 2014), and to prevent players from feeling "lost" or confused as proposed by (Consolvo et al., 2008; J. Yim and Graham, 2007), are related to the first two recommendations in table 7.4. Their guidelines aim at providing the player with the necessary knowledge to prevent them from feeling "lost" or confused, and the first two recommendations in table 7.4 aim at providing the user with a greater understanding of both the game play and the surrounding world (e.g. by augmenting it with a map showing the location of a challenge).

Lin et al.'s guideline (Lin et al., 2006) to "avoid negative consequences" as the result of the player's low performance aligns with recommendations 3 and 4 of table 7.4: alignment of the social and physical context is essential to avoid frustration and trigger negative emotions, which, in turn, lead to lack of willingness to play. Yim (J. W. Yim, 2008)'s insight that "multiplayer collaborative exercise games are more motivating and engaging than single-player exercise games" is specific to online multiplayer collaborative games, rather than competitive ones.

Recommendation 6 of table 7.4 is similar but for different reasons. Challenges where the adolescents could propose new ideas on their own without involving others (e.g. type Inventor) did not trigger substantial interaction of any type. On the contrary, challenges where the adolescents had to compete against, and collaborate with, one another, were very successful at maximising social interaction. Even during the challenges were the adolescents were meant to engage with strangers (which could have triggered interaction with strangers only), they supported one another because they were together (meaning more interaction than single-player challenges). Recommendation 7 of table 7.4 relates to previous findings (Inal and Cagiltay, 2007; Stein et al., 2018), that advocate adjustment of the difficulty of the challenges to the adolescents to maximise their immersion in the game and improve overall gaming experience.

Existent research on game rewards and physical activity (Smeddinck et al., 2019) is associated with recommendation 8, as game play sessions that include exercise, and reward players for that, can lead to more motivation and further exercise. Still in regard to recommendation 8, one guideline proposed by literature that this research does not directly endorse is the "incorporation of music to motivate players to exercise" (Laamarti et al., 2014; J. Yim and Graham, 2007). Statements collected from the adolescents during this research show that the activities they enjoyed most were the ones where they had physical exertion and the ones where they had to engage with strangers. The challenges that were designed for physical exertion in this research (type Athlete) had no music involved, and yet, the adolescents were strongly motivated by these, which makes us argue that physical exertion is a key factor for adolescents' motivation. In-game music was not considered at all in the game design explored in this case study, but designers could explore its applicability for player motivation in future games for meaningful social interaction in public space.

7.3.2. Limitations and future work

All recommendations are based on our experience with the SotS game, a limitation in itself. The data from this research is bound to the specific social context of the chosen location. The studied environment is limited due to its uncontrollable restrictions such as the control that the teachers and researchers had to maintain for the safety of the adolescents. This study had certain experimental conditions that led to the reported findings of the study, which could have been different had other experimental conditions been tried out (e.g. having adolescents use their own smartphone, one smartphone for the whole group, or having adolescents interacting only with their friends). This study was made with young adolescents, with a narrow age range, and this limits the generalisation of the findings. Still, and even though each group age has a specific predisposition for specific forms of interacting with others, the SotS game is based on the requirements of the studied ages of adolescents and adults, which not only contribute to gameplay sessions that go in line with the way the studied age groups want to interact, but also strengthen the certainty on the findings of this study. Strangers in particular were involuntary participants of this study, and the results of the study could differ if only voluntary participants would be considered. Still, the researchers believe that the mentioned uncontrollable restrictions add to the realism of the study, which aims at fostering social interaction in a way that is meaningful to players: fostering interaction with volunteers only would potentially influence the results, but arguably not in a realistic way.

Further research is needed to understand whether similar findings hold for different social contexts and age groups that are bound to different countries, socio-economic realities, and different cultural norms and values. Analyses of both the usability of the developed technological artefact (Brooke, 1996), and the levels of engagement in the game (GEQ) (Brockmyer et al., 2009) could shed light on aspects such as presence, flow, absorption, and dissociation and possibly be related to meaningful social interaction: subject for future research. No statistical analysis was made in this study, and future research can explore potential statistical relationships between for example challenge categories and player experience with regard to social interaction, as well as system usability.

7.3.3. SUMMARY

This chapter presents a case study that aimed at exploring two research questions, meant to evaluate the SotS game prototype in: 1) if and when meaningful social interaction occurred during game play of this case study and how, with which impact, and 2) the design choices/features that contributed to (the experience of) meaningful social interaction. It conducts a case study where the gameplay of the same participants from chapter 4.4 (creators of specific game ideas for their neighbourhood) test their preferred ideas, and reports on the observations made and reports from users themselves on how they felt playing the SotS. Regarding the first question, social interaction indeed occurred with the gameplay offered by the SotS, the gameplay was enjoyed by players for the most part, and that, based on the definition used in this research for meaningfulness, a few types of game activities provided players with a meaningful interaction. The explored game design of the SotS supports co-located experiences in the players' neighbourhood, and different types of game activities invite different forms of interaction, which vary for e.g. in their level of difficulty, exposure to outside of the comfort zone, and competitive/collaborative levels. Regarding the second question, this chapter analyses the different types of challenges and the dynamics of play they afforded, through looking specifically at 1) levels of enjoyment players had in playing the challenges, 2) positive play experiences, 3) levels of complexity in solving the challenges, 4) behaviours of collaboration and competition elicited from players, 4) types of interaction, 5) how meaningful such interaction was to players, and 6) levels of engagement with the designed content of the game (i.e. challenges offered). Lessons learned led to the guidelines offered, which help future practitioners in adapting future LBGs to the physical space and its social context, to what users prefer playing, and successfully craft a gameplay that can lead to meaningful social exchanges.

8

Discussion and Future Work

I'm a chemistry guy. I believe you've got to play together to have a chance to win.

Tony Gwynn

This thesis started from the importance of communication and interpersonal relationships that are core to mankind's wellbeing, and from the fact that social interaction, when of quality, can have far reaching implications that go well beyond the individual. This is of particular importance given that the nature of current societies is highly diverse, and with issues whose solutions are not really known. Many initiatives have been attempted to address many of these issues and make societies more cohesive and resilient, yet not only cities are organised in such a way that issues are perpetuated, but the very constructs of cohesion are not well understood. These lead any initiative in society a delicate process, as failure to properly understand what unites and how to meaningfully bring communities together can lead initiatives to have the opposite effect and pull communities apart. This thesis addresses this lack of understanding on what cohesion is, and takes the position that interaction-based initiatives of quality can make societies more resilient and cohesive.

From that understanding, this thesis researched the use of play as a positive approach to promote social interaction of quality in public space. Play has always "played" a role in the formation of society, as it is a fun-based approach for the creation of room for enhancement of culture and for meaning to be formed across individuals (Ehrmann et al., 1968; Huizinga and Seresia, 1952). Particularly, it zoomed in on location-based games (LBGs), as a technological form of play that is particularly suitable to inviting citizens to the streets and engaging with others in play. LBGs offer potential to that end, as they are media packed with locative sensors that position players and sense their contextual environment. Yet, they are a relatively recent tool that require complex game designs capable of using technology to its full potential and provide players with a gameplay that is appropriate to the way they want to play. As a consequence, numerous LBGs have been created, both research prototypes and commercial ones, that seem to be "blind" attempts to get such complex game designs right.

This thesis argued that the use of LBGs specifically for the promotion of meaningful social interaction raises several problems.

On the one hand, meaningful interactions are person-dependent (Putnam, 1975), and LBGs for this specific purpose can only work if the users' preferences, needs and desires for their own interactions with their fellow neighbours are understood. This is of paramount importance, as social interaction can occur in multiple ways (Bardis, 1979), and the preparation of a gameplay that can have positive impact on local social cohesion needs to account for what is meaningful to players. On the other hand, it is not well understood how to build location-based games for such purpose[1] (Straker et al., 2014):

1. it is not known which requirements should be considered in the design of LBGs for social interaction (Daneva, 2014; Fonseca, Lukosch, Lukosch, and Brazier, 2020; Isbister and Mueller, 2015; Valente et al., 2017);

2. the involvement of future players in the design of LBGs have mostly been play-centric (involved in play testing the game at later stages) and not user-centric (involved in most stages including requirements elicitation);

3. there are no known guidelines for the content that LBGs should present to players so that they are invited to socially interact with others and be exposed to their neighbourhood;

4. to build LBGs, several perspectives and expertise are needed, and literature scarcely covers a technical perspective mandatory for the creation of LBGs: that of the systems' architecture (Avouris and Yiannoutsou, 2012; Naliuka et al., 2010; Söbke and Streicher, 2016)

This thesis took the position that LBGs for social interaction have specific requirements that require the implementation of specific functionality that must be covered at this technical level to be successful (Fonseca, Lukosch, Lukosch, and Brazier, 2020; Fonseca et al., 2017; Fonseca et al., 2021; Slingerland, Fonseca, et al., 2020), and, at the level of game design, requirements must be further understood to have LBGs lead players to the specific behaviour of meaningful interactions in public space (Fonseca, Lukosch, Lukosch, and Brazier, 2020; Fonseca et al., 2017).

8.1. Research questions

Given such gaps and challenges, this thesis explored the following main research question: **"Can location-based games be designed for meaningful social interaction in public space?"**. The main goal of this thesis was to investigate if and how it is possible to design and build LBGs capable of triggering social interaction in public space, a form of interaction that is meaningful to players. As a response to the main research question, this thesis showed that it is possible to design and build an LBG that triggers meaningful social interaction in the neighbourhood of players. This thesis explored the type of requirements that different target groups have to be exposed to their neighbourhood and engage in interactions

[1] https://mashable.com/2016/07/10/john-hanke-pokemon-go/?europe=true, How the gurus behind Google Earth created 'Pokemon Go', last visited on December 23, 2020.

with both their fellow players and passers-by. It also explored what LBGs for social interaction require from a technical perspective to provide such gameplay, and, together with the lessons learned from the users, it reported on a built and tested game prototype that is capable of offering gameplay experiences that are overall enjoyable for players, and enjoyable or neutral for individuals involved in the gameplay.

To help answer the main research question, three sub-research questions were elaborated, the first of which being: **"Which needs and requirements are essential in location-based games for social interaction in public space?"**. Chapters 2, 3 and 4 addressed this sub-research question by specifying specific needs and requirements.

Chapter 2 firstly focused on the lack of understanding on what social cohesion is, to better comprehend the way to best position LBGs for a positive social impact. It offered a comprehensive literature survey on the complex construct of cohesion, discusses multiple definitions and perspectives that scholars have been using to study it, and 1) suggested a more up-to-date definition with which to look at current multicultural and multi ethnic communities, and 2) proposed a framework with which to characterise social cohesion and different perspectives that can be taken to influence it. These contributions stem from the numerous definitions and perspectives used by scholars to understand and define cohesion, from which it is evident that 3 pillars exist. These (the individual, communities, and institutions) inform this research on what influences the complex construct of cohesion, and what can be considered to have positive impact. Chapter 2 concluded with social interaction being a basic social exchange supporting more complex social phenomena such as cohesion, and as such it is defined as the very first and essential requirement for location-based games for social interaction in public space.

Chapter 3 performed a background check on the literature related to games for social interaction in public space, and what it is known so far on how to design them for meaningful social interaction. It specifically covered any existent guidelines that might be useful in this research, game components that are known to lead players to specific behaviour, and what should be considered when building location-based games for social interaction in public space (from the perspective of systems architecture). This chapter exposed current gaps in knowledge on the way to prepare LBGs for this purpose, and informed on 1) the lack of guidelines for the creation of these games, 2) the way practitioners make attempts to building these games without really involving future players from early stages of design, 3) the fact that there is no consensus on what game elements to consider during game design for deterministic behavioural outcomes, and 4) the lack of consensus on which architectural components are key in LBGs for social interaction. This chapter concluded with the argument that location-based games for meaningful social interaction in public space mandate the involvement of future players in early stages of game design, as their preferences, needs and desires for their exposure to the public space and interaction with others are central to the gameplay's success.

Chapter 4 took on the conclusion from previous chapter, and expanded current understanding of players' needs and requirements essential to them. It presented four case studies, 2 with adolescents in Rotterdam and 2 with adults in The Hague, where it is studied the specific social contexts of future players, and researched their specific requirements for the aimed gameplay. It discovered a specific set of game dynamics that adolescents want to have while playing LBGs for social interaction. These are: *achievement*, *real-world play*, *reinforcement*, *social interaction*, *collaboration*, *digital interaction*, *ownership*, *winning condition*, *collection*, *exertion*, *virtual representation*, *mission*, *community contribution*, and *lottery*. These were considered to be essential high-level requirements regarding the functionality of the game: they guide the choice and arrangement of game elements and mechanisms to provide the run-time dynamics of play desired by players.

Chapter 4 also addressed the sub-research question by discovering 7 types of activities that both adolescents and adults desire to play: activities that require players to do physical activities (**Athlete**), find information and factual knowledge (**Detective**), explore their neighbourhood (**Explorer**), propose ideas and explore opportunities (**Inventor**), find specific things or people (**Hunter**), create and express thoughts, feelings, interests in some form (**Artist**), and contribute to the environment and help others (Fonseca et al., 2018a; Slingerland, Fonseca, et al., 2020) (**Volunteer**). LBGs to be able to provide meaningful social interaction must provide game content that players want to play, and these activity types are therefore necessary to the defined aim. Chapter 4 further explored the needs and desires of players by eliciting specific game ideas, and properly mapping them to the mentioned activity types. This set of activities was co-designed together with future players for co-located social interaction, and inform exactly on 1) the activities they want to play (by themselves and with others) and 2) the locations they want to play them at. These activities were also considered as requirements for the specific LBG pursued in this thesis, given that they require specific functionality to be proposed to players during gameplay. Chapter 4 concluded with an analysis on the forms of social interaction triggered by each activity type, which adds to current understanding on what should be presented to players to invite specific interaction-based behaviour desired by them. These lessons learned were taken as requirements, as they lead to the way users prefer to interact with others and their environment.

8

The second sub-research question this thesis asks was: **"Can a generic system design be created and implemented for location-based games for meaningful social interaction?"**. Chapters 5 and 6 answered affirmatively to this sub-research question.

Chapter 5 explored LBGs from a technical perspective, gathered current understanding on what system components are needed for them to sustain social interaction in public space, and argued that essential architectural components for LBGs with this aim are (Fonseca, Lukosch, and Brazier, 2020a): **Augmentation**, **Navigation**, **Interaction**, **State Progression**, **Participation**, and **Administration**. These components provide the functionality needed to represent the environment of players, locate them, facilitate interaction with other players/environment/physical objects, track the gameplay state, enable long-term play for players through participation, and manage the game. Chapter 5 concluded with a modular software architecture being proposed that LBGs should implement to invite and sustain social interaction in public space, as it contains the mentioned key architectural components. This answered the first part of the sub-research question, as a generic system design is proposed in the form of this modular software architecture.

Chapter 6 gathered all the lessons learned from both the users' essential needs and desires, and the generic system design, and proposed the implementation of a fully open-source game prototype: the 'Secrets of the South' (SotS). This LBG is a product of an iterative design approach where user requirements were repeatedly elicited, and where all initial requirements, constraints, and user requirements were taken into account to produce a game capable of facilitating meaningful social interaction. The SotS implements the generic system design proposed in the previous chapter, is an actual game that is capable of promoting in-situ social interaction, and with a platform that allows users to contribute with what they believe is important for other players to play. Chapter 6 concluded with a detailed account on all the design choices taken throughout the process. The proposed system prototype answered the second half of the second sub-research question, by proving that a location-based system can be implemented for meaningful social interaction in public space.

The third and last sub-research question was: **"Can design recommendations be identified for interaction in location-based games for social interaction in public space?"**. Chapter 7 explored and proposed several design recommendations.

Chapter 7 validated the developed game prototype SotS presented in the previous chapter, through a case study that assessed 1) if and when meaningful social interaction occurred with it, and with which impact, and 2) the design features and choices that contributed to the experience of meaningful social interaction. It showed that the SotS creates opportunities for social interaction, specifically in-group interaction, interaction with people not known by players, and engagement with the physical environment. Many of these interactions were meaningful to players, as they were excited to engage with as many strangers as possible, were kind to others, and felt great by simply trying to help others.

From the lessons learned, together with literature, Chapter 7 concluded with design recommendations that are applicable during the game concept definition. These recommendations provide a basis for future designs of LBGs aiming for meaningful social interaction. For social interaction in specific, they should: 1) be location-aware, 2) augment and mediate the gameplay, 3) offer game content aligned with the considered physical location, 4) such content should be tailored to the social context where they are played, 5) the content must be adjusted to players' understanding of the world, 6) multiplayer challenges provide greater social interaction, 7) provide game content that offers variety, and 8) consider physical exertion. On top of these, three design recommendations specific to meaningful social interaction are also recommended: 9) *Hunter*-type challenges for all types of meaningful social interaction (in-group, with unknown people, and with environment); 10) mostly *Hunter* and *Explorer* types of challenges for within group interaction and with unknown people; and 11) *Hunter* and *Volunteer* types of challenges for meaningful in-group interaction. These answered affirmatively to the third sub-research question: design recommendations can be identified for LBGs designed for social interaction in public space.

The lessons learned on this thesis help better understand 1) the process involved in the creation of an LBG for meaningful social interaction in public space, and 2) the various essential requirements involved for the success of such game. With regard to 1) (the process), creating an LBG for this purpose involves a long and iterative approach that places future players and their preferences and needs at its centre. By doing so, it is possible to tailor the gameplay experience of the game around players, and elicit specific game content that engages them most. Design recommendations proposed in this thesis shed light on what to consider in the design and development process, and offer better comprehen-

8

sion on the specific forms of interaction that specific activity types foster. With regard to 2) (requirements), essential requirements are revealed for LBGs with this purpose to be successful. Firstly, gameplay requirements are proposed to help game designers focus on the game world and the elements and mechanics required to implement the gameplay dynamics desired by players. Secondly, specific activity types are revealed, and these shed light on what players are looking forward to have as game content. Lastly, essential architectural building blocks are identified, without which LBGs cannot successfully offer meaningful social interaction in public space.

8.2. Contributions

This thesis has the following main contributions: 1) a new definition for social cohesion, 2) a social cohesion framework, 3) a set of gameplay requirements for LBGs aiming at fostering social interaction in public space, 4) a framework of activity types for games of this type and purpose, with a relationship between activity types and the form of interaction they promote, 5) a set of specific and reusable game ideas for the identified purpose, 6) a list of architectural components that are key for games of this type to support the mentioned purpose, 7) a modular software architecture with the key architectural components, 8) an LBG prototype, and 9) design recommendations.

The first contribution of this thesis is a new definition for social cohesion. Several definitions have been commonly used for this complex social construct around the world, such as those used by the Council of Europe (CoE, 2008), Canadian Government (Jeannotte, 2003), and OECD (de Cooperación y Desarrollo Económico, 2011). However, these definitions fail to address and embrace the multicultural facet of current societies. The proposed definition stresses the important role of multiculturalism, and the values of tolerance, voluntary participation, and diversity in society that embellish the construct of cohesion.

The second contribution is a social cohesion framework. The framework shows the connections and inter dependencies between the individual, the community and institutions, needed to be taken into account to better comprehend and study social cohesion in the future. It stems from all the factors, perspectives and levels found in the literature on cohesion, and goes beyond the body of literature by clarifying which pillars sustain cohesion and explaining which factors are associated to each pillar. The factors included in each of the three levels propose measures to impact and measure cohesion, while being at the same time generic enough to be extended by other factors not currently mentioned for clarity purposes.

The third contribution is a set of gameplay requirements for LBGs with the aim to foster social interaction in public space. Even though the game dynamic achievement is predominant, all of the identified game dynamics are important, and indicate to a varying degree what adolescents would like to experience in future games fostering social interaction. This set of gameplay requirements is proposed, based on in-depth analysis of aesthetics and dynamics using the MDA framework (Hunicke et al., 2004). A methodology for the analysis of users' requirements for location-based games is used (based on the Triadic Game Design (Harteveld, 2011) - for the elicitation of the worlds of reality, meaning and play of future players, and on the MDA framework - for the distillation of game dynamics from generated game ideas), which can be used by other researchers and practitioners to derive gameplay requirements from users. An extension of the MDA framework is suggested, with the inclusion of a new aesthetic called "Care" (required to cover aspects mentioned by users and specifically attached to social interaction).

The fourth contribution is a framework of activity types for LBGs for social interaction in public space, with a relationship between these activity types and the form of interaction they promote. This thesis proposes 7 types of activities that are most effective in fostering social interaction in public space. All of these activity types initiate social interaction and capture the real life gameplay needed to advance in the game. The framework offered by this thesis also furthers current understanding of the interaction that different types of activities elicit based on the nature and types of exchanges they entail, as it can be used by designers in 1) the analysis of game activities in existing games (in which one or more of the 7 types of activities are embrace), and 2) the design of new game activities to specifically target one or more types of interaction. The proposed framework provides a means with which to increase current understanding of the impact of LBGs for social interaction on local communities, that in turn can be embraced to foster adolescents' and adults' sense of belonging towards their own neighbourhood.

The fifth contribution of this thesis is a set of specific and reusable game ideas for LBGs aiming at fostering social interaction in public space. This set provides "food for thought" for game/activity design that different users (adolescents, and adults) prefer. Adolescents showed to prefer activities that 1) involve physical exertion and contact with friends, and that 2) explore the world surrounding them and engage with face-to-face conversations with people living in their neighbourhood. In turn, adults enjoy activities where they 1) discover the neighbourhood (also through digital means such as QR codes, as long as the technology used is familiar to them), 2) see there is a purpose (e.g. sharing meaningful information about the neighbourhood with others) and that use historic land marks, and 3) have opportunities for natural conversations and face-to-face collaboration with other people. The specific game ideas can be reused by practitioners of game design when preparing future games targeting the same neighbourhoods studied, and/or serve as inspiration for similar game activities for LBGs for social interaction in public space.

The sixth contribution is a list of architectural components that are key for LBGs to successfully support social interaction in public space. This list enhances the understanding on which architectural components are essential to design and implement to support a type of gameplay leading to the aimed purpose. It stems from commonalities in essential functionality that different successful LBGs[2,3,4,5,6,7,8] share. These components are key because without them: the game would not be able to represent the environment of the player (*Augmentation*) or assist him/her in the location-based game play that is central to this genre (*Navigation*); multi-modal interaction with other players and the environment would not

[2] https://www.geocaching.com/play, Geocaching, last visited on December 23, 2020.

[3] https://www.pockettactics.com/guides/location-based-games-ios-android/, The best location-based & GPS games on mobile, Jan. 2020, last visited on December 23, 2020.

[4] https://www.redbytes.in/gps-mobile-game-development-ios-android-2018/, Best GPS location-based games on iOS and Android 2018, Oct. 2017, last visited on December 23, 2020.

[5] https://beebom.com/best-location-based-gps-games/, 8 Best location based GPS games you can play, Jul. 2017, last visited on December 23, 2020.

[6] https://www.businessofapps.com/data/pokemon-go-statistics/, Pokemon Go revenue and usage statistics (2019), May 2019, last visited on December 23, 2020.

[7] https://www.pocketgamer.com/games/004719/parallel-kingdom/, Parallel Kingdom, last visited on December 23, 2020.

[8] https://wayfarer.nianticlabs.com/, Niantic© Wayfarer!, last visited on December 23, 2020.

be possible (*Interaction*); tracking of the interaction with physical/digital objects, the game play, and every game-like progression would not exist (*State Progression*); contribution and involvement of players both at the level of content and maintenance of game play would not be possible, rendering long-term game play of an LBG designed for social interaction obsolete (*Participation*); and the centralised orchestration and management of the game, required for the consistency of the game, would render the game unplayable (*Administration*).

The seventh contribution of this thesis is a modular software architecture based on the identified key architectural components. The modular software architecture not only guides designers and developers on which components to include, but also that they benefit from a modular approach that grants freedom of implementation. This aids designers and developers without constraining either their creativity (through a too detailed method) nor their freedom of choice (of how to implement each component). The proposed modular software architecture provides guidance on how to create a system for an LBG that can potentially trigger social interaction in public space. This modular software architecture supports the six components identified, and can be extended to include other components for other types of functionality as needed. This architecture provides future game designers and developers of LBGs support for less complex game design and development processes, while leaving room for creativity and modular implementations.

The eighth contribution is an LBG prototype that is capable of inviting players to have meaningful social interaction in public space. The LBG prototype ('Secrets of the South' - SotS) has been developed and tested with children, adolescents and adults in The Hague and Rotterdam, the Netherlands, where it was shown to successfully foster social interaction. The SotS is proposed after a 4-step general procedure that put future players at its centre, and implements 1) all the identified user requirements documented in this thesis, and 2) the proposed modular software architecture with all key architectural components. SotS provides opportunities for players to interact with both their friends and (un)known passers-by, invites them to the real physical environment of the neighbourhood and its social context, and offers opportunities for social interaction that is overall positive to players and positive or neutral to others involved (Fonseca et al., 2021; Slingerland, Fonseca, et al., 2020).

Lastly, the ninth contribution of this thesis is a set of design recommendations. These design recommendations regard design choices made during game concept definition, and provide a basis for future designs of serious games for meaningful social interaction to be made based on the experience reported in this thesis and in the literature. These design recommendations are distinguished from the specific requirements on game dynamics for the game world that LBGs with this purpose should implement which, unlike such game dynamics, do not concern the actual implementation of the gameplay.

8.3. Future Work

With regard to the construct of social cohesion, future research should focus on the influence of and between each of the levels (the individual, community, and institutions) on the design and implementation of interventions for social cohesion. All three pillars play a role in the upkeep of social cohesion, as well as the type of cohesion observed. Future research should explore how local communities react and evolve based on interventions at the level of each of the pillars individually and combined. This will enhance current understanding on the relative importance of each of the pillars for cohesion, which in turn can result in more efficient designs of interventions. In turn, interdisciplinary studies can shed light on interrelated processes affecting more than one pillar. The nature of each pillar mandates the consideration and use of different disciplinary perspectives (potentially combined), and it must be better understood up to which point cohesion-related phenomena are interrelated. The improvement of current understanding on cohesion and what/how affects it must be further studied to be clearly understood in which way current societies can become more (socially) resilient.

The improvement of current understanding on what/how affects cohesion would also potentially require an update to the social cohesion framework (SCF) that is proposed in this thesis. The SCF is a tool with which social cohesion can be characterised in is levels and aspects, regardless of the perspective taken. Future research can further develop the SCF (a generic framework) into a more detailed tool. With a more detailed SCF, practitioners and researchers can better characterise the social cohesion observed in different locations, by comprehending which phenomena is playing a role in the observed cohesion. It would also develop a better understanding of how it varies from one level (e.g. micro level - the local community of the individual) to another (e.g. macro level - the overall society), and the reasons why.

Another important aspect for future work is the need to further current understanding of the preferences, needs, and desires of users. With regard to adolescents, this thesis explores the requirements that adolescents of specific neighbourhoods in the South of Rotterdam, The Netherlands, have. Different social contexts, even the same country, can potentially reveal details that are not apparent to game designers, highlighting not only the importance of involving future players in the process of requirements elicitation, but also the potential for games to explore novel ways to expose adolescents to their surroundings and the people in them. Future studies need to further current understanding of the studied target group, by not only considering higher numbers of participants in the same/similar social contexts, but also by considering the different participants of the same target group but completely different social contexts.

Still with regard to the preferences, needs and desires of adolescents for social interaction in their neighbourhood, a limitation of the type of case studies performed (based on gamified workshops) is that it is possible that different preferences, game ideas, and ultimately desired game dynamics can be elicited through similar, or even different workshop designs. Priming of adolescents took place to aid the creative process of idea generation, and future work should elicit the adolescents' requirements through different setups than those documented in this thesis. Such research can reveal if and how adolescents' preferences change with regard to the game dynamics desired by them, or if they tend to be similar/the same. This thesis argues that all the lessons learned with regard to gameplay requirements are important and indicate to a varying degree what users of this age group would like to experience in future LBGs fostering social interaction. Yet, future work can reveal other predominant game dynamics, particularly if the pool of participants becomes more gender balanced. Not only on other predominant game dynamics, future work must further specify the identified game dynamics which are at a high level, by for example proposing possible design patterns that describe how to put game mechanics and elements together to provide these dynamics of play. It is recommended that such future work includes a user-centric research through design methodology, as it covers an often overlooked perspective that can bring about key knowledge on users, their context, and their preferences.

Beyond the gameplay requirements, another finding of this thesis that needs to be further studied is the extension of the MDA framework (Hunicke et al., 2004) used to analyse game ideas and extract dynamics of play. This thesis proposes the inclusion of "Care" as aesthetic, given that the original framework did not completely cover everything that the involved adolescents mentioned. Future work should propose an empirical analysis on the validity of this new aesthetic, all the while researching what other aesthetics could exist and be included. As human emotions are numerous and complex, having a more complete taxonomy of aesthetics can help structure the process of game design and make it less dependent on individual game designer's preferences. In addition, the relationship between the list of game dynamics identified in this paper and the degree to which social interaction is fostered, should be further explored. Future work in this direction will shed light on the relative importance of each requirement with respect to the form of social interaction involved.

Future work can also go a step beyond and analyse what is known so far with regard to the relationship between mechanics, dynamics and aesthetics, and potentially propose more advanced tools to more efficiently extract actionable game dynamics/mechanics/elements from game ideas proposed by users. This thesis makes an analysis at the levels of aesthetics and game dynamics, as it considers that an analysis at the level of mechanics would be too detailed. Yet, it is often not well understood what possible dynamics and mechanics there are, and even though the concepts of game "mechanic" and "dynamic" are well defined, no comprehensive tool of analysis exists, where a detailed and unanimously agreed upon list of mechanics and dynamics is offered. Such comprehensive tool of analysis can be studied in the future.

As continuation of this thesis, an avenue for further research is the improvement of engagement levels that LBGs for social interaction can provide. The framework of activity types that is proposed in this thesis is a product of several case studies on the way different user groups prefer being exposed to their own neighbourhood and interact with the people in it. Future work can further explore how these activity types can foster higher engagement levels of immersion in the overall intended game experience, through a variety of game elements and novel technical artefacts such as augmented reality, puzzles, or sensors/actuators from the internet of things more recently found in smart cities. Location-based games already offer numerous possibilities with ever evolving sets of hardware/software tool kits, and future work should not only drive the game design further into what location-based games can technically support, but also exploit 1) LBGs in combination with technology that can more seamlessly interact with the real environment, and 2) combine elements and mechanics to drive engagement towards purposeful interaction in public space.

This thesis researches different user groups and their preferences, needs and desires for an interaction-based gameplay. In general, future work could focus on scaling the research up by involving more participants and from a wider age group. With regard to adults, discovery is an important motivator for citizens to explore their neighbourhood. Future work should address discovery and how it can be properly used in the game design to sustain engagement with a longer-term gameplay. Discovery is something that can be done only once per location, person, or story. On the one hand, current research indicates that reflections on a familiar place can support the discovery of new meaning (Jones et al., 2019), and future research can explore whether re-doing gaming activities in the same locations can be done in such a way to gradually discover more details about a location or story. On the other hand, games have been exploring ways to allow citizens to add game content and fuel a gameplay that provides players with the possibility to keep discovering new parts of the game (Slingerland, Fonseca, et al., 2020). Future research can explore if player participation is enough to fuel a longer engagement with the game and the play it invites. It is also subject of future work the inclusion of other actors beyond citizens, in the longer-term maintenance of LBGs for social interaction. The discussed gameplay takes place within the urban environment, and public institutions, such as local governments or community centres, are actors that can become players of the game and take a more participatory role in it. Future work can focus on how different LBGs can bring different actors together, and promote player engagement based on content and activities that appeal to the local social context of players.

Another way future research can address discovery is through the exploration of the balance between discovery and familiarity that works best for adults, given that the discoveries that can be made through the game must relate to their daily lives. This is a complex research avenue, for participants have different levels of familiarity even when it comes to their neighbourhood, and lack of familiarity may not have a direct impact on engagement during gameplay. The case studies with adults reported in this thesis argue that other factors such as the gaming activities or personal interests played a role in player engagement, and future research can shed light on exactly what factors played a role in player engagement (and how exactly they manifest) in LBGs for social interaction.

With regard to adolescents, research shown in this thesis argues that adolescents have distinct preferences for activity types when compared to adults. Yet, similar to the studies done with adults in this thesis, only a limited number of participants, locations and social contexts were used to research user preferences and needs. Further research is required to generalise the lessons learned with regard to activity types, and it should consider different locations, and other participants of the same target group. Future work will be able to map in more detail the sort of activities that each target group likes (or has a tendency to like), and, with each group, make a potential distinction based on gender or other criteria. It is also possible that future research reveals more types of activities, or that the preferences of users change for example in function of time (different generations) or place (different countries).

Still with regard to the activity types that LBGs should offer to engage players in social interaction with (un)known people, future research needs to be done on the activity types and the forms of interaction they are designed to promote. The analysis offered in this thesis is based on literature alone, and the strength of the findings can be enhanced in future studies with case studies designed to practically experiment and observe the triggered interactions, and that correlate those interactions with the types of activities found. Such future research can then expand the framework of activity types advanced in this thesis, and turn it into a more detailed and reliable instrument with which 1) existent games can be analysed in the forms of interaction they trigger, and 2) new game activities can be designed in such a way to target a desired form of interaction. Furthermore, the temporality of the interactions as a result of gameplay can be investigated further for all challenge types. For instance, whether social interactions are sustained after gameplay and whether some challenge types are more effective in supporting sustained interactions than others, between players and/or people involved in the gameplay.

In the context of this thesis, specific game ideas were co-designed with adolescents to 1) provide "food for thought" for game/activity design, and 2) better understand their preferences, needs and desires. The specific game ideas generated in this thesis also represent a two-fold limitation for future re-usability: they are specific to adolescents (the adolescents that participated), and to the neighbourhoods studied. Even though the co-designed set of ideas serve the purpose of serving as inspiration for the creation of future game content specific to adolescents and the studied areas, future work should address these limitations by co-designing ideas that appeal to 1) similar target groups but other locations, and 2) different target groups in both the same and different locations. Such work will help shed light into specific game activities that engage players most, which can not only influence the actual game designs proposed to future players but also further what is known about activity types and forms of interaction.

This thesis proposed a list of architectural components that are key for LBGs to successfully support social interaction in public space. Important aspects for future work are the evolution of technology based on which LBGs can offer more engaging and successful gameplay experiences, and the consideration of novel aspects in game design explored by different and more recent LBGs. On the one hand, the technology available to LBGs dictates what is possible to explore, and it is likely that future hardware/software innovations will mandate the consideration for other architectural aspects currently not highlighted. On the other hand, the list of architectural components that is proposed in this thesis is based on the analysis of successful LBGs that are appreciated by millions of players, yet, newer games are always being proposed. Future research should compare the list of architectural components with newer successful games, and explore if there are other architectural components that also play a key role in meaningful engagement with LBGs designed for interaction. Further work should also empirically analyse the relative importance of each of the architectural components to the desired purpose: LBGs for social interaction in public space, where players engage in neighbourhood exploration and social encounters with (un)known people.

With regard to the modular software architecture proposed in this thesis, which also builds on top of the identified list of architectural components, future work can further improve and expand its level of detail. The proposed architecture aims at guaranteeing that designers and developers know which architectural components to include, all the while granting freedom of implementation. Future work can provide further ways to expand the proposed architecture. Firstly, this can be done by exploring novel or existent frameworks, online platforms, and online services that are specific to games and can sustain more complex game designs. Doing so can lead to the use of more realistic maps or immersive gameplay experiences, and trigger other phenomena that was not considered in this thesis and that can be studied in their impact on social interaction in public space (e.g. immersion, flow). Secondly, research on the specific social context that local communities have, or newer insights on social resilience, cohesion or interaction, can shed light on other interesting gameplay experiences relevant for meaningful interaction. Considering an ever evolving body of knowledge, and different ways of implementing the proposed modular architecture, not only helps designers make interesting gameplays to ever changing players and requirements, but broadens up current understanding of how to technically build LBGs for social interaction. Thirdly, future research can focus on exploring ways to expand the proposed software architecture with other secondary modules to target the provided architecture to even more specific purposes within interaction (e.g. shared fun, cooperative public work, or neighbourhood exploration). To these more specific interaction-based purposes, other secondary modules may prove to be valuable extensions to the essential key components proposed in this thesis. Lastly, the proposed architecture aims at making the process of game design less complex, and it can be considered as the first step in that direction. Future work can broaden the work done in this thesis to further simplify the design and development of LBGs for social interaction. One example on how this can be done is the creation of IT tools capable of generating a game skeleton, upon which developers can quickly implement their specific game design and address all essential pieces for a successful game.

In the context of this thesis, the 'Secrets of the South' (SotS) is a prototype of a location-based game that is developed for social interaction in public space. However, at this stage of design, it is not prepared to be used "out of the box" without technical expertise. In its current version, the presented game could benefit from further development to make it more readily accessible to other locations, easier to use and contribute with game content, and lower the technical adoption barrier. Future work could focus on these aspects, propose an online platform that offers the possibility for any citizen to promote gameplay in his/her local community, and even make the SotS accessible to specific purposes that different social actors may have. An example of this is schools, and the adaptation of the SotS to the development of 21st century social skills in informal educational settings. Further work on such an online platform could allow the SotS to be used to promote social encounters throughout the city in a straightforward way (targeting the studied age groups), and allow different actors to be in charge of the design of the gaming activities (e.g. local tourism, neighbourhood exploration). Such work should also create a set of guidelines based on those reported in this thesis, to be easily accessible by those actors.

The SotS game prototype requires further evaluation to more strongly measure its impact in different target groups, and within the same target groups in other social contexts. The design recommendations reported in this research stem from our experience with the SotS game, and future work should aim at generalising these recommendations. Further empirical evaluations should be done with a bigger number of participants, in locations with similar and different social contexts, different target groups, and even other LBGs designed for the same purpose as the SotS. Further research is needed to understand whether similar findings hold for different social contexts and age groups that are bound to different countries, socio-economic realities, and different cultural norms and values. The referred design recommendations are based on a game prototype that stems from what adolescents with a narrow age range informed as preferences and needs. Therefore, the created game prototype provides a gameplay experience that is biased towards specific forms of interacting with others that are preferred by the studied age groups, which is a limitation that needs to be addressed in the future. The SotS overall game prototype benefits as well from being further tested in its usability (Brooke, 1996) and triggered engagement levels (Brockmyer et al., 2009). Doing so can shed light on aspects such as presence, absorption, and dissociation, which can affect the triggered social interaction and its meaning to players. Such work can be complemented with statistical analyses on the relationships between aspects offered in the SotS, for example challenge categories and player experience with regard to social interaction.

Lastly, the research done aimed for gameplay experiences occurring during (or that are close to) the real life of the participants involved (both players, and the unfamiliar people involved in the gameplay). Such conditions are more complex to study, given that they are permeated with uncontrollable restrictions (such as the control that the teachers and researchers had to maintain for the safety of the adolescents), uncontrollable variables (such as specific cars on the street or who is walking through a given location), and conditions that influence lessons learned (different conditions can lead to different findings, such as having participants use their own smartphone, one smartphone for the whole group, or having participants interacting only with their friends). Strangers in particular were involuntary participants of the reported case studies in this thesis, and the results could differ if only voluntary participants would be considered. This thesis argues that the uncontrollable restrictions add to the realism of the study, which aims at fostering social interaction in a way that is meaningful to players: fostering interaction with volunteers only would potentially influence the results, but arguably not in a realistic way. Future work should explore both realistic interaction settings and more controlled setups, as doing so would greatly expand what is known about the best way to design for meaningful social interaction when mediated by LBGs.

A

Supplementary material of case study in sub-chapter 4.1

This appendix contains the material supporting the case study in chapter 4.1: the structures of the workshops done, and the analysis done with the MDA tool, for the aesthetics and dynamics composing the game ideas.

A

A.1. STRUCTURE OF THE WORKSHOP 1

Time	Activity
13h15 – 13h45	Joint lunch
	Introduction | Setup of Workshop
13h15 – 13h35	Introduction, who we are, what are we going to do. Give the domain of the game and the problem. Provide 1 to 3 small examples. Mention the reward of cookies :P
13h35 – 13h45	“Challenge: Create a multi-player outdoor game for your neighbourhood”. Form groups of 3 to 5 people each, make an assignment to create a context.
	World of Reality
13h45 – 14h10	- Identify your neighbourhood by indicating the area on a map of Rotterdam - Characterize the neighbourhood, and the things and people that play a role in your neighbourhood (people, organizations, artefacts, phenomena, etc.); - Draw a picture showing the relations between the identified people/objects; - Do a pitch of each group’s idea, and attribute points;
14h10 – 14h15	Introduce the purpose on slide and paper: “Create a game to involve as many people in the neighbourhood as possible. MAKE IT FUN!”
	World of Meaning
14h15 – 14h40	- Form groups for the strategy: figure activities for you to do (or could do) with other people; - Brainstorm activities that would lead to the joint game activities; - Identify the major players of the game (who do you think should be part of the game, even if not directly playing the game); - Where (major locations), when (the game is to be played), and how (with which devices) will the game be played? - Define a title/name for the game;
14h50 – 15h05	Break
	World of Play
15h05 – 15h45	Playing cards PlayGen, for the genre of the game (for each colour, 10 minutes). One worksheet to summarize results
15h45 – 15h55	Rethink title
15h55 – 16h10	Pitch and points
	Feedback
16h10 – 16h45	Open discussion of workshop / feedback; Price ceremony and hand over a TU Delft participation certificate
16h45	End

Table A.1: First structure for workshop 1.

A.2. STRUCTURE OF THE WORKSHOP 2

Time	Activity
	Introduction | Setup of Workshop

09h30 – 10h10
40 min (20 for the game)
	- Introduction, who we are, what are we going to do. Give the domain of the game and the problem.
	- Let's play a game (depending on the conditions, either Squaring the Circle, or Moon Ball) – Rules attached. (connect by saying: as you needed to work together and interact with everybody to succeed in this task, so you will have to do in the next game)
	- "Purpose: Create a game to involve as many people in the neighbourhood as possible. MAKE IT FUN!".
	    - Provide 1 to 3 small examples.
	    - Link each of them to the purpose criteria.
	- Mention the prize for the winning team!
	    - Form 3 groups (5 people each)

	World of Meaning
10h10 – 10h50 **40 min**	- "What activities do you want to (or could) do with other people?" (Brainstorm activities that would lead to the joint game activities) - "Where do you want to play the game, and why?" (I want them to think about the places they know, and what these have to offer, because if it isn't their neighbourhood, they might quickly describe the "general feeling" of the area and how they want to change it). - "Who do you think should play the game with you, for Rotterdam to become a happier place?" Give examples (neighbours, policemen, firemen, businessmen, etc.). (In here I want to know the agents to be included in the game). - When is the game played (day, night, etc.)?
10 min	Break.
	World of Play

11h00 – 11h40
40 min
	- Playing cards PlayGen, for the idea of the game. (for each colour, 10 minutes; 1 to 3 game ideas).
	- For each game idea, ask:
	    ▪ How is the game played (sticks, graffiti's, lasers, trampolines, avatars, technology, etc.)?
	    ▪ Give a Title.
	- One worksheet to summarize results. Choose one worksheet to compete with other groups.

11h40 – 11h55 **15 min**	Pitch and points
	Feedback
11h55 – 12h10 **15 min**	- Open discussion of workshop / feedback; - Price ceremony and hand over the prizes / certificates;
12h10	End

Table A.2: Revised structure for workshop 2.

A

A.3. GAME IDEA ANALYSIS: MDA

The MDA framework can be used to analyse game ideas through different but interrelated ways: aesthetics, dynamics, and mechanics (Siriaraya et al., 2018). Aesthetics are the targeted emotions evoked in the player, resultant from dynamics observable during the game play, which are in turn implemented through several particular game mechanics. The MDA framework advances a list of nine aesthetics, but does not do the same for neither dynamics nor mechanics. On the one hand, aesthetics, defined as the emotions evoked in the player during his or her interaction with the game, are on a very high level for requirements. On the other hand, mechanics, or the particular components of the game, are too fine grained. Dynamics are defined as *"the run-time behaviour of the mechanics acting on player inputs and each other's outputs over time"* (Siriaraya et al., 2018).

For the purpose of requirements analysis, this research analyses all game ideas at the level of dynamics. Per game idea, it is analysed how each aesthetic is elicited from the player, and then, per aesthetic, it is analysed how it is achieved in terms of dynamics. The 9 aesthetics are described as follows:

- **Sensation** is when the player experiences something completely unfamiliar to them;
- **Fantasy** is when the player gets caught up in an imaginary world, and tied in to something that they feel could exist. This is what fuels the player's feeling of immersion;
- **Narrative** makes a story which drives the player to keep coming back, where the player wants to figure things out;
- **Challenge** is when the player feels the need to master something. Planning for this aesthetic is what boosts a game's replay value;
- **Fellowship** is portrayed when a community is formed that the player is actively a part of. Encouraging multiplayer interaction increases fellowship;
- **Discovery** is fuelled by the players need to explore. Vast worlds and secrets so players can explore at their own will. Also, give the player reason to explore (special gear, increased stats, bonus levels...);
- **Expression** occurs when players play to use their own creativity or leave their mark. Character creation will allow players to showcase their avatars, and take pride in their work;
- **Submission** is when a player literally 'submits' themselves to the game. The player is bound or constrained by mechanics, but they love it the entire time;
- **Competition**, in/explicit, (in)direct contest or rivalry;

Throughout the analysis of the game ideas, several game dynamics emerge. However, to be easier for the reader to follow the analysis, and to allow a more concise presentation of the analysis, the full list of game dynamics is presented and defined upfront. The definition of these game dynamics are as follows:

Dynamic	**Definition**
Achievement	Provide a sense of accomplishment to the player, either as an individual or as a group, resultant from task completion;
Collaboration	Enable players to achieve a shared goal by working together, which may be necessary to advance the game play;
Collection	Promote the player returning to the game, by creating an objective of collecting items in the game that can be accomplished throughout time and several game plays. Collection is the act of gathering game elements in the game environment (either digital or real world) for the purpose of ownership, trade, or improvement of condition;
Community Contribution	Impact the real environment, outside of the game, by involving people not actively playing the game or creating positive consequences of the game play in the rhythm of the neighbourhood;
Digital Interaction	Promote play and engagement by influencing communication between players, while also allowing them to influence the game play of other players in the digital world. Digital interaction happens for e.g. in the form of communication, digital group formation, or multiplayer mode;
Exertion	Motivate players to do activities involving physical effort, which creates a different approach for them to advance in the game. This involves physical effort that is required to perform an activity or solve a challenge linked to the game;
Lottery	Add surprise to what the game originally presents to the player, and prevent the player from getting used to the game. It is done through random events that affect the game play or its outcome;
Mission	Add fantasy and overall purpose to the game play, usually through a tale, general narrative, or as overall mission. It can also be achieved by smaller missions that add to the overall tale;
Ownership	Make players participate, own and be responsible for part of the game content. Players participate in the game by bringing in content, and that content is a contribution that makes players (partially) own the game and influence other player's game play;
Real-World Play	Embed the play in the physical environment and allow the player to be physically active;
Reinforcement	Foster play and engagement, e.g. a reward given in case a certain action or outcome occurs;
Social Interaction	Establish interaction and face-to-face communication, either with other players or with people not actively playing the game;
Virtual Representation	Promote the player in the game by digitally representing the player's state, visibility, or social status;

A

Table A.3 (continued)

Winning Condition	Quantify success and accomplishment within the game. A winning condition either implies a comparison and competition between players, or a competition between the player and the game. These are required conditions to complete game tasks;

Table A.3: Aesthetics of the MDA framework (Hunicke et al., 2004).

The following tables show the full game analysis for each game idea. They show which game aesthetics are present per game idea, and, per aesthetic, how the aesthetic is implemented with the identified game dynamics.

A. G1 - Keep on Running

Aesthetic	Dynamic	Reasoning
Fantasy	*Players deal with monsters in the team's quest to accomplish tasks*	
	Achievement	Present in the game as the sense of accomplishment from dealing with monsters
	Mission	Used in this game for accomplishing tasks as a team
Challenge	*Players accomplish challenges, finish assignments given by other players, look for virtual and physical objects, have tasks being randomly assigned to their group, and have challenges of different natures (virtual and physical).*	
	Achievement	Occurs when players accomplish challenges in this game idea
	Collection	Players look for, and collect, virtual and physical objects
	Digital Interaction	Players create challenges for others, receive points with the other team's success, and messages are sent for players to form a team
	Exertion	The challenges in Keep on Running can be of physical nature, such as running, sprinting, or dancing
	Lottery	Challenges are randomly assigned to teams
	Social Interaction	Players need to perform challenges together with other players
Fellowship	*Players send out messages to nearby players, enter the game and form a group, have challenges being performed as a group, have individual players partially contributing to the overall success of the group, and get points from other team's success.*	
	Achievement	Players are capable of forming a group with other players and jointly solve challenges
	Collaboration	Challenges have to be performed as a group and partial solutions count for the group's progress

Table A.4 (continued)

	Digital Interaction	Players send out messages to nearby players and form a group
	Reinforcement	The incentive of getting points from the other team's success
	Social Interaction	Players physically perform challenges in close proximity with the group
Discovery	*Players look for virtual or physical objects in the environment to collect items/gold, have the game throw random tasks to the groups, and have challenges of virtual and physical nature that make them discover the surroundings.*	
	Collection	Collect items/gold
	Lottery	Random tasks are thrown to the group
	Real-world Play	Players walk around and look for objects in the surrounding environment
Expression	*The game allows players to use items to personalise the player's avatar, show the player's progress with the avatar, represent the player's state with that avatar, and allows groups and individuals to create new challenges for the other group to complete.*	
	Achievement	Player's status in the game represents how far the player is in the game
	Ownership	Players participate in the game and own the challenges created for the other team, which allows them to express themselves
	Reinforcement	Personalised avatar shows progress in the game
	Virtual Representation	Players personalise their digital avatar and show their state in the game via the avatar
Competition	*The game fosters competitions between two groups of players, and players can finish a challenge first, earn gold by accomplishing challenges and by having a winning team.*	
	Achievement	Finish challenges, create challenges for others, compete and beat another group
	Collaboration	Compete with another group as a team
	Exertion	Challenges of physical nature, such as running or sprinting
	Reinforcement	Earn gold by winning
	Winning Condition	Players need to finish the challenge first, which is a winning condition and leads to competition
N/A	*Aesthetics not present in game:* ***Sensation***, ***Narrative***, ***Submission***.	

Table A.4: Game analysis of G1: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

A

B. G2 - RealCraft

Aesthetic	Dynamic	Reasoning
Sensation	*The aesthetic **sensation** is included by having players discover other players' creations. The game play of this game is also expected to be scalable up to the whole city or country, which makes players potentially experience unfamiliar game play.*	
	Achievement	Players need to be able to discover the creations of others
	Community Contribution	This game has the potential to impact the livability of the location where the game play occurs
	Ownership	Players own their creations
	Virtual Representation	The game promotes visibility, i.e., players can find other players and their creations
Fantasy	*The aesthetic fantasy is included by having players building virtual objects, fighting against enemies, and collecting assets from the environment.*	
	Achievement	Players are able to build objects they ideate
	Collection	Collecting assets
	Real-world play	Walking around the environment
Narrative	*Present through the storyline of fighting against enemies.*	
	Mission	The game has a purpose that is clear to the player
Challenge	*Included by having players collecting assets and building virtual objects, fighting against enemies, winning battles and building objects, and doing that when together with other players and in combination with different types of assets.*	
	Achievement	Players must fight and win, and build objects that are complex or made of different types of assets, which contributes to sense of accomplishment when h/she is successful
	Collection	Players can build objects when together with other people
	Real-world play	Players have to walk around the environment to build objects in certain locations
	Social Interaction	Same as collection
Fellowship	*Present by having the player building objects in the environment together with other players, having other players being able to see the objects built by a player, having players exchanging messages to trade, collaborating, building, and actually trading and exchanging assets with other players.*	
	Achievement	Collaborate and build
	Collaboration	Players have to building objects together

A

Table A.5 (continued)

	Collection	Trade objects
	Digital Interaction	Send messages, trade objects
	Ownership	Built objects are left for others to see
	Real-world Play	Walk around the environment to build
Discovery	*Present through the collection of assets from the environment, and setting of the environment at Zuiderpark.*	
	Achievement	Collecting several assets means being successful at that
	Collection	Collection of assets
	Real-world play	Game play in the real environment
Expression	*Included by having players improving and customising the avatar, and using different combinations of types of assets to build their objects.*	
	Achievement	Players have to build more complex objects by combining assets
	Virtual Representation	The existence of avatars
N/A	*Aesthetics not present in game:* ***Submission***, ***Competition***.	

Table A.5: Game analysis of G2: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

C. G3 - The Voice of South

Aesthetic	Dynamic	Reasoning
Sensation	*Present in this game through the performance of players, and of making music.*	
	Ownership	Players contribute with performances and are responsible for them
	Real-world Play	Players have to do real performances in the real environment
Challenge	*Players record people singing or making music in the neighbourhood.*	
	Achievement	Players are able to perform, make music, and sing in the neighbourhood, which contributes to the sense of accomplishment and success
	Ownership	Players own their performances and contribute to the game
	Real-world Play	Players perform in the real environment

A

Table A.6 (continued)

Fellowship	*The game enables other players to listen the performance of players on the spot.*	
	Reinforcement	Players receive support while performing, and that allows for togetherness to be fostered
Discovery	*Players make music in the neighbourhood.*	
	Real-world Play	Players have to walk around in the neighbourhood and choose the place to perform, the audience they have, and everything related to the environment
Expression	*Players perform (sing, rap, make music).*	
	Achievement	Sense of accomplishment after a successful performance
	Exertion	Performances (dancing) might involve physical effort.
	Real-world Play	Players need to walk around the neighbourhood to perform or record others
Competition	*Included in the game idea by having the best songs/raps/clips of the player's performances being put on top of leader boards, and having social status and visibility as a result.*	
	Reinforcement	Leader boards, status, and visibility show the ranking (appreciation) that the players got with their performances
	Virtual Representation	Players compete for the best social status and visibility of the performer
	Winning Condition	The game allows players to differentiate performances by ranking the best songs, which makes players compete for the best rankings
N/A	*Aesthetics not present in game: **Fantasy**, **Narrative**, and **Submission**.*	

Table A.6: Game analysis of G3: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

D. G4 - Water Ball

Aesthetic	Dynamic	Reasoning
Sensation	*Incorporated in this game idea through the engagement with other players.*	
	Digital Interaction	Players throw balls to people with the smartphone
	Social Interaction	Face-to-face contact with people is promoted through the virtual interaction mechanism
Challenge	*Players throw virtual balls at each other, and get points from hitting different players.*	
	Achievement	To be able to find a different person and hit her

A

Table A.7 (continued)

	Collection	Gather different contacts throughout the game play
	Digital Interaction	Mechanism of interaction, of throwing digital balls to players
	Reinforcement	Receive points for successful hits
	Real-world Play	Find players in the real world
Fellowship	*Present in the interaction occurring between the player and other players, which makes them get to know one another.*	
	Achievement	Players have to find new people to interact with
	Social Interaction	Face-to-face interaction with people that promotes communication
	Real-world Play	Such communication happens in the real world environment
	Reinforcement	Successful interactions plus the points collected incentive further ones and reinforce fellowship
Discovery	*Included when the player enters in contact with people in the environment and has to search for people to hit with the ball.*	
	Achievement	The player hast to hit other players, which in this case also triggers further discovery
	Social Interaction	Face-to-face interaction with people that promotes communication
	Real-world Play	Such discovery happens in the real world environment
	Reinforcement	Successful interactions plus the points collected incentive further ones and reinforce fellowship
Competition	*Incorporated in the game idea by having players targeting different players due to the threshold put in place on the maximum points per person, which makes the game distinguish players' achievements through the amount of points.*	
	Achievement	Players target several different people
	Reinforcement	Players earn points
	Winning Condition	There is a competition between the player and the game on the number of points
N/A	*Aesthetics not present in game: **Fantasy**, **Narrative**, **Expression** and **Submission**.*	

Table A.7: Game analysis of G4: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

E. G5 - Eat & Go

Aesthetic	Dynamic	Reasoning
Sensation	*Present when players are able to experience the excitement of beating other players.*	
	Achievement	Players get to finish challenges and feel successful
	Winning Condition	Players are able to beat other players and be better than them at a challenge
Challenge	*Included when players challenge other people in sports, trade points for free and more varied food over time, discover new food and become healthier, and solve challenges randomly encountered while walking around.*	
	Achievement	Players perform in sports competition and discovering food
	Collaboration	Players do joint activities with other players
	Exertion	Physical effort in the competitions done
	Lottery	Challenges are randomly thrown to players
	Ownership	Players are responsible for "bringing" challenges to other people
	Real-world Play	Players discover new food around the real environment
	Reinforcement	Players can get points and trade them for a variety of food
	Winning Condition	Players do challenges against other people
Fellowship	*Present in the game idea when players form a group, eat together, and do activities together.*	
	Achievement	Players form a group and accomplish activities as a group
	Collaboration	Players accomplish activities as a group
	Community Contribution	Players do activities that might include people not actively playing the game
	Reinforcement	Players accomplishing activities as a group get points
	Social Interaction	Players do activities and are together
Discovery	*Integrated in the game by having players walking around and challenging people around them.*	
	Collaboration	Players do joint activities with other players
	Ownership	The more people participate in creating challenges to be solved, the more game play experience in public space is fostered
	Real-world Play	Walking in public spaces

Table A.8 (continued)

	Winning Condition	Players do challenges against other people
Expression	*Included as challenges allow for expression, e.g. via flash mobs.*	
	Achievement	Players are capable of expressing in public
	Community Contribution	Impact the neighbourhood with a prolonged game play by making people perform in such challenges for food
	Real-world Play	The game makes people walk around the neighbourhood and solve challenges in the real environment
	Reinforcement	Players are rewarded for successful challenges done.
	Social Interaction	Interact with other people or players face-to-face when challenging them
Submission	*Included in the game by having points being collected as a group, which means the players have to submit to the group's intentions or rules in a specific challenge.*	
	Achievement	Players are able to support the group in the task
	Collaboration	There is a notion of group and the group's goal
	Ownership	Players are responsible for the individual contribution
	Social Interaction	In the collaboration, players interact in person
	Winning Condition	The group has to beat other(s) in the task
Competition	*Present when players beat other players in sports competition, and doing challenges makes player win or lose points.*	
	Achievement	Players have to beat others in competitions
	Collaboration	A group of players has to collaborate to beat another group
	Exertion	The competitions can involve physical effort
	Real-world Play	Such competitions happen in the environment
	Reinforcement	Players gain points from beating other players
	Social Interaction	Competitions involve more people competing at the same time
	Winning Condition	Players have to beat others in competitions
N/A	*Aesthetics not present in game:* ***Fantasy****, and* ***Narrative****.*	

Table A.8: Game analysis of G5: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

There is a component of this game that is not covered with the current list of aesthetics, which is the adaptation of the game to things other than food, joint activities such as voluntary work or providing help in repairing things for others, or doing things together such as cooking or eating (without winning conditions). This is implemented with the dynamics *community contribution* (some challenges have a direct impact in the neighbourhood, as they involve collecting garbage or voluntary work), *real-world play* (walking around Zuiderpark), *collaboration*, *achievement* (helping others, contributing to something outside the game play), *ownership* (participating in the game play and contributing for a good cause), and *social interaction* (the nature of the tasks involve face-to-face communication and interaction).

This research proposes the aesthetic "**Care**" to cover this. This aesthetic is an aesthetic for players looking for a *gameplay aimed at giving back to the community*. Games with this aesthetic invite players to engage in offline community building, care for the community, the environment, and the people in it.

F. G6 - Minecraft GO

Aesthetic	Dynamic	Reasoning
Fantasy	*Included in the game by having natural disasters testing the players' creations, while letting players own a region.*	
	Achievement	Players succeed when buildings withstand natural hazards
	Ownership	Players can own a region and build whatever structure they would like to have in it
	Winning Condition	Players succeed when buildings withstand natural hazards
Narrative	*Present in the game in the story line and related assignments of the game.*	
	Achievement	Players succeed by completing tasks
	Mission	There is a story line with an overall mission and smaller assignments for the game
Challenge	*Players have to see whether their own buildings can withstand natural disasters, go through the assignments of the game, own a region and keep it intact, and trade with other players to advance in the game.*	
	Achievement	To see whether the structures built withstand the hazards
	Collaboration	Trading with other players to advance in the game
	Digital Interaction	Trading with other players
	Ownership	Own a region through building a village and other constructions
	Reinforcement	The success of having the structures built withstanding the hazards
	Winning Condition	The success of having the structures built withstanding the hazards

A

Table A.9 (continued)

Fellowship	*Players become part of the fantasy of others, trade construction objects, build with other players, create their villages and invite friends to build with them, and advance throughout the game by making friends.*	
	Achievement	Players have to make enough friends to advance
	Collaboration	Players contribute to the fantasy of others, and make friends
	Collection	Players have to make enough friends to advance
	Digital Interaction	Trade, make friends
Discovery	*Players move around the neighbourhood to get unique resources, while exploring the whole neighbourhood.*	
	Achievement	Players have to collect items spread across the environment
	Collection	The act of collecting unique resources
	Real-world Play	Players have to walk around the neighbourhood to explore it and collect materials
Expression	*Players place content everywhere in the neighbourhood, create places for playing with each other and meeting each other in real life, create a personal logo, and have a personalised style.*	
	Achievement	The amount of structures build and left around the neighbourhood leads to the sense of accomplishment
	Community Contribution	Players start hanging out in common places
	Ownership	The contribution the player makes to the game in terms of constructions
	Real-world Play	Players place content everywhere in the neighbourhood, which implies walking around
	Reinforcement	The rewards of having multiple content, social status and visibility stemming from the player's creations
	Social Interaction	Face-to-face interactions in these places
	Virtual Representation	Players get social status and visibility of the logo plus avatar
Submission	*Included by having players submitting themselves to other players' villages and wishes (e.g. construction style).*	
	Achievement	Players build something
	Collaboration	Players build something together with others
	Digital Interaction	Players communicate and agree on what and how to build
	Reinforcement	Rewards from having helped another player in his or her village

A

Table A.9 (continued)

	Virtual Representation	Players leave their mark behind in the overall construction of others
	Winning Condition	Players collaborate with others player to build a structure that withstands natural hazards
Competition	*Players compete with other players for the biggest number of buildings, and try to own regions.*	
	Achievement	Players beat other players and own something
	Collaboration	It is necessary to create a region together with other players
	Collection	Number of buildings
	Digital Interaction	It is necessary to create a region together with other players
	Ownership	Players bring new creations to the region to make it bigger than those of other players
	Winning Condition	Players have to have the biggest number of buildings
N/A	*Aesthetics not present in game:* ***Sensation***.	

Table A.9: Game analysis of G6: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

G. G7 - GTA Rotterdam

Aesthetic	Dynamic	Reasoning
Sensation	*Incorporated in this game idea by having players chasing and evading other players.*	
	Achievement	Players have to chase, evade, or catch someone
	Exertion	Players have to run and grab others
	Real-world Play	Game play happens in an outdoor environment
	Social Interaction	Physical play together with other people
	Winning Condition	If players get caught, they lose
Fantasy	*Players have to find fictitious items such as drugs, and they have a water gun and a dog at their disposal to help chase suspects.*	
	Achievement	To find drugs and chase suspects
	Digital Interaction	Interaction with other players in the virtual world
	Mission	To find drugs and chase suspects

A

Table A.10 (continued)

	Social Interaction	Digital interaction leads to face-to-face interaction
	Virtual Representation	Players are represented in the virtual world in order to be found
Narrative	*Present throughout the game assignments requiring players to follow somebody, kidnap, and to discover drugs or things.*	
	Achievement	To discover and find suspects
	Mission	The overall purpose of the game
Challenge	*Present in the game via the negotiation that players have to do between themselves, the assignments they have to solve (follow people, abduct, finding something or someone, and discover hidden drugs), and the speed and efficiency players have to have to have a better score.*	
	Achievement	Players have to find things
	Collaboration	Players have to interact and collaborate through negotiations
	Digital Interaction	Players have to interact and collaborate through negotiations
	Reinforcement	The score of a performance, i.e. how much water was used, and the amount of time required to catch someone
	Real-world Play	Players have to find things in the real environment
	Social Interaction	When someone is found, kidnapped, or chased
Fellowship	*The support players have to provide for each other, and the ability to message other players with their mobile phones.*	
	Collaboration	Support each other throughout the game play
	Digital Interaction	To communicate but also support other players
Discovery	*The safe places in the environment that players need to discover, and the people they need to follow, find, abduct, or text to support them in safe places.*	
	Achievement	To follow and find suspects in the environment
	Digital Interaction	To follow and find suspects involves digital game mechanisms
	Mission	Walk around to find the safe places, on top of solving the challenges
	Real-world Play	Walk around to find the safe places
	Social Interaction	To follow and find suspects involves interaction

A

Table A.10 (continued)

Competition	*Players chase or are chased by others, protect themselves in safe houses, and become the fastest and the better at solving the assignments (which means less water used and more points).*	
	Achievement	Players solve assignments, perform better, and interact along the game play with other players
	Digital Interaction	Players interact with other players (with water gun)
	Exertion	The physical nature of the game play, i.e. chasing and evading
	Real-world Play	Players look for safe zones and stay in such locations
	Reinforcement	Players receive more points when they beat others
	Social Interaction	Players interact along the game play with other players
	Winning Condition	Be the fastest, using the least amount of water
N/A	*Aesthetics not present in game:* ***Expression****, and* ***Submission****.*	

Table A.10: Game analysis of G7: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

H. G8 - Habiba Challenge

Aesthetic	Dynamic	Reasoning
Sensation	*Supported in this game via the excitement of teaching each other new activities.*	
	Achievement	Players are capable of teaching something to someone
	Collaboration	Players want to help out and teach someone
	Ownership	The responsibility for the contribute given to the game and other players or people
	Real-world Play	Activities are done in the real world
	Reinforcement	The explicit or implicit rewards of helping someone out
	Social Interaction	Players do activities together with other people
Challenge	*Players have to eat the biggest amount of chicken or hitting each other with a softball.*	
	Achievement	Players have to be good to solve challenges
	Exertion	Challenges are of physical nature and involve effort
	Real-world Play	Challenges ate to be done in public spaces

Table A.11 (continued)

	Social Interaction	Face-to-face communication is involved in these challenges
	Winning Condition	The challenges involved require players to beat others by performing better
Fellowship	*Present by having players collaborating and teaching each other new activities.*	
	Achievement	Players need to successfully collaborate and teach, which leads to other players learning new things
	Collaboration	Collaboration is present in challenges requiring players to learn or do new activities
	Community Contribution	Players want to contribute to the community by helping citizens
	Ownership	Players choose to actively participate in helping citizens out
	Social Interaction	The nature of the challenges involves face-to-face interaction
Discovery	*Players learn new activities from other players, assign new challenges to other players and discover the outcome when other people play them.*	
	Community Contribution	The creation of a community of players that know each other and do activities together in the environment
	Reinforcement	Players help people and other players, and the help received (a social exchange creating social capital) promotes further game play and serves as a reward to the one helping
	Social Interaction	Players do activities together in the real world
Expression	*Players can develop their own challenges and attribute those to other players.*	
	Achievement	Create and own successful challenges
	Collection	Players are responsible for numerous challenges they created
	Digital Interaction	Players assign challenges to one another
	Ownership	Players bring content to the game and own it
	Virtual Representation	The more challenges players create, the more other players will know about them, meaning social visibility
Competition	*Players hit each other with a soft ball, win challenges and get points, and aim at the highest score by winning the game.*	
	Exertion	Hitting with a soft ball involves physical activity
	Reinforcement	Players get points

A

Table A.11 (continued)

	Social Interaction	Hitting with a soft ball involves face-to-face encounters
	Winning Condition	Highest score wins
N/A	*Aesthetics not present in game: **Fantasy**, **Narrative**, and **Submission**.*	

Table A.11: Game analysis of G8: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

I. G9 - The Walking Egg

Aesthetic	Dynamic	Reasoning
Fantasy	*Players build and manage a farm.*	
	Achievement	Players need to successfully build and manage the farm they have
	Ownership	Players become responsible for the farm they manage
Narrative	*The game has a mission and side missions.*	
	Mission	There is an overall purpose in the game of building a farm.
Challenge	*Players solve the main mission and the side missions, collect bonus points with side missions and collectables, give the possibility to use real money to acquire points to buy new eggs and farm upgrades like armours, and throw eggs to other players to get points.*	
	Achievement	Solving missions and hitting other players with eggs
	Collection	The existence of collectable items, farm upgrades, and new eggs
	Digital Interaction	Throwing eggs as the digital mechanism of interaction
	Mission	There is an overall purpose in the game of building a farm.
	Reinforcement	Points collected when successfully hitting other players
	Social Interaction	Throwing eggs to interact with people in person
Fellowship	*Included through voice communication, multiplayer mode, and the possibility of scanning QR codes of other players both online and in real life.*	
	Collaboration	Communication, scanning others' QR codes
	Collection	To collect friendships counted in QR codes
	Digital Interaction	Communication, scanning others' QR codes
	Reinforcement	To collect friendships counted in QR codes
	Real-world Play	To find players in real life

Table A.12 (continued)

	Social Interaction	To find players in real life
	Virtual Representation	Personal identification with a QR code
Discovery	*Present as a map with the real surroundings, and as the players walk around in real life.*	
	Real-world Play	Players discover the real environment through the game
Expression	*Players can manage their own farm, and can make and dress up their avatar.*	
	Achievement	Players have to be successful at managing a farm
	Ownership	Players are responsible for the their own farm
	Virtual Representation	Players have an avatar, and the social visibility that comes with both the avatar and the farm built
Competition	*Players have to throw eggs to other players to get points, and compete in free runs against others.*	
	Achievement	Players have to hit other players with eggs
	Exertion	E.g. free running
	Real-world Play	Running against each other
	Reinforcement	Players get points
	Social Interaction	Running against each other
	Winning Condition	Players compete and beat other players in free running
N/A	*Aesthetics not present in game: **Sensation**, and **Submission**.*	

Table A.12: Game analysis of G9: aesthetics present (explained in *italics*), and dynamics implementing each aesthetic.

A

A.4. REQUIREMENTS RESULTING FROM THE ANALYSIS ON THE MOST RELEVANT DYNAMICS

This section analyses each of the aesthetics in terms of how they tend to be implemented by the dynamics that emerged from the analysis of the game ideas. The goal is to understand what are the dynamics that tend to be present the most throughout all the game ideas and aesthetics, and consider those as desired functionality by the participants in future games for social interaction. This is done by counting how many times a given dynamic occurs in the game ideas and in each aesthetic (as different aesthetics in the same game idea can use different dynamics).

The game ideas are referred to in the tables from table A.13 to table A.21, as: G1 - Keep on Running, G2 - RealCraft, G3 - The Voice of South, G4 - Water Ball, G5 - Eat & Go, G6 - Minecraft GO, G7 - GTA Rotterdam, G8 - Habiba Challenge, and G9 - The Walking Egg.

A. Aesthetic "Sensation"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G2	•			•					•				•	
G3									•		•			
G4					•							•		
G5	•													•
G7	•					•					•	•		•
G8	•	•							•	•	•	•		
Total	4	1	-	1	1	1	-	-	3	1	3	3	1	2

Table A.13: Game Dynamics implementing the aesthetic "Sensation".

Based on table A.13, the aesthetic "sensation" is implemented mostly by the dynamic achievement.

B. Aesthetic "Fantasy"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G1	•							•						
G2	•		•								•			
G6	•								•					•
G7	•				•			•				•	•	
G9	•								•					
Total	5	-	1	-	1	-	-	2	2	-	1	1	1	1

Table A.14: Game Dynamics implementing the aesthetic "Fantasy".

Based on table A.14, the aesthetic "fantasy" is implemented by the dynamic achievement (present in all of the game ideas with this aesthetic).

C. Aesthetic "Narrative"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G2								•						
G6	•							•						
G7	•							•						
G9								•						
Total	2	-	-	-	-	-	-	4	-	-	-	-	-	-

Table A.15: Game Dynamics implementing the aesthetic "Narrative".

Based on table A.15, the aesthetic "narrative" is implemented by the dynamic mission (present in all of the game ideas with this aesthetic).

D. Aesthetic "Challenge"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G1	•		•		•	•	•					•		
G2	•	•	•								•	•		
G3	•								•		•			
G4	•		•		•					•	•			
G5	•	•				•	•		•	•	•			•
G6	•	•			•				•	•				•
G7	•	•			•					•	•	•		
G8	•					•					•	•		•
G9	•		•		•			•		•		•		
Total	9	4	4	-	5	3	2	1	3	5	6	5	-	3

Table A.16: Game Dynamics implementing the aesthetic "Challenge".

Based on table A.16, the aesthetic "challenge" is implemented by the game dynamic achievement in every game idea, followed up by real-world play, and to a lesser extent by the dynamics digital interaction, reinforcement, and social interaction.

E. Aesthetic "Fellowship"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G1	•	•			•					•		•		
G2	•	•	•		•				•		•			
G3										•				
G4	•									•	•	•		
G5	•	•		•						•		•		
G6	•	•	•		•									
G7		•			•									
G8	•	•		•					•			•		
G9		•	•		•					•	•	•	•	
Total	6	7	3	2	5	-	-	-	2	5	3	5	1	-

Table A.17: Game Dynamics implementing the aesthetic "Fellowship".

Based on table A.17, the game dynamics implementing the aesthetic "fellowship" best are collaboration, achievement, reinforcement, social interaction, and digital interaction, being the game dynamic collaboration present the most.

F. Aesthetic "Discovery"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G1			•				•				•			
G2	•		•								•			
G3											•			
G4	•									•	•	•		
G5		•							•	•	•			•
G6	•		•								•			
G7	•				•			•			•	•		
G8				•						•		•		
G9											•			
Total	4	1	3	1	1	-	1	1	1	3	8	3	-	1

Table A.18: Game Dynamics implementing the aesthetic "Discovery".

Based on table A.18, the aesthetic "discovery" is clearly defined by the game dynamic real-world play.

G. Aesthetic "Expression"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G1	•								•	•			•	
G2	•												•	
G3	•					•					•			
G5	•			•						•	•	•		
G6	•			•					•	•	•	•	•	
G8	•		•		•				•				•	
G9	•								•				•	
Total	7	-	1	2	1	1	-	-	4	3	3	2	5	-

Table A.19: Game Dynamics implementing the aesthetic "Expression".

Based on table A.19, the aesthetic "expression" is implemented by the game dynamics ownership, virtual representation, and, in all game ideas, achievement.

H. Aesthetic "Submission"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G5	•	•							•			•		•
G6	•	•			•					•			•	•
Total	2	2	-	-	1	-	-	-	1	1	-	1	1	2

Table A.20: Game Dynamics implementing the aesthetic "Submission".

Based on table A.20, the aesthetic "submission" is implemented by the game dynamics achievement, collaboration, and winning condition. Even though the other dynamics were mentioned, these 3 are present in all of the game ideas containing this aesthetic.

I. Aesthetic "Competition"

	Achievement	Collaboration	Collection	Community Contribution	Digital Interaction	Exertion	Lottery	Mission	Ownership	Reinforcement	Real-world play	Social Interaction	Virtual Representation	Winning Condition
G1	•	•				•				•				•
G3										•			•	•
G4	•									•				•
G5	•	•				•				•	•	•		•
G6	•	•	•		•				•					•
G7	•				•	•				•	•	•		•
G8						•				•		•		•
G9	•					•				•	•	•		•
Total	6	3	1	-	2	5	-	-	1	7	3	4	1	8

Table A.21: Game Dynamics implementing the aesthetic "Competition".

Based on table A.21, the aesthetic "competition" is implemented in every game idea by winning condition, and mostly by achievement, reinforcement, and exertion.

As a summary, it is possible to count the number of occurrences of each dynamic throughout the aesthetics and game ideas (the last row of each table, from table A.13 to table A.21. The game dynamic achievement is the dynamic that implements the game ideas and the aesthetics the most, being present 45/81 times. Real-world play (27/81), reinforcement (25/81), social interaction (24/81), and collaboration (18/81) are the dynamics that follow up that implement the game ideas fostering social interaction the most. Digital interaction, ownership, and winning condition (17/81) scored equally, meaning that the capability of digitally interacting, participating in the game's content, and having winning conditions seem to hold the same importance for the participants. On the lower spectrum, collection (12/81), exertion (10/81), virtual representation (10/81), mission (8/81), community contribution (6/81), and lottery (3/81) are the dynamics desired the least by the participants. However, these are still argued as being mentioned and desired by the participants.

This indicates, to a varying degree, what participants of this target group wish to see in a future serious game fostering social interaction. Thus, these are considered as desired requirements for future serious games designed to foster social interaction.

B

Supplementary material of case study in sub-chapter 4.2

Challenge designs used in the case study 4.2 and presented to players in the game prototype:

- Challenge 1 ("**The Hague City Hall**"): The city hall of The Hague, is located in the new city centre, and incorporates the council chamber, the main public library, as well as cafes, exhibition spaces, and a wedding room. At its centre is a large atrium, which is said to be the largest atrium in The Netherlands. The building is nicknamed "the Ice Palace" (Dutch: IJspaleis) for its white colour. You have to estimate the volume of the atrium. You have 5 minutes. The closer the answer to reality, the bigger the reward.

- Challenge 2 ("**Plein**"): The Plein is a large town square. It was constructed in 1632 and was made to look like the Place Royale (currently Place des Vosges) in Paris. Due to the close proximity to the Dutch parliament, it is also often used for political demonstrations. In the Dutch parliament, all the governors have to collaborate in order to shape the future of the Netherlands. Your task will be exactly like this: to make a geometric shape with a rope (polygon, triangle, hexagon, etc.) while blindfolded. The faster you make it as a team, and the more complex, the bigger your points :) You can communicate.

- Challenge 3 ("**The Royal Cabinet of Paintings**"): The *Mauritshuis* is a museum that contains over 841 objects in exposition, mostly from the Dutch Golden Age. The collections contains works by Johannes Vermeer, Rembrandt van Rijn, Jan Steen, Paulus Potter, Frans Hals, Jacob van Ruisdael, Hans Holbein the Younger, and others, it is now the property of the government of the Netherlands and is listed in the top 100 Dutch heritage sites. Back in the days, as it is told by the locals, the only way for artists to publish one of their works at a museum would be to contact a secret organisation called the Apetrots, where they would have to prove their mastery by duelling one of the members of that society. If the artist would win, he would get paid by the piece.

Otherwise, it would be taken for free. You have to fight for your right of free drinks, like artists did back then. Unite with your group, and make a performance of the three musketeers fighting for a princess (choose the princess). The better the performance, the bigger the reward. PS: the music is a bit different 3:)

- Challenge 4 ("**Binnenhof**"): The *Binnenhof* (English: Inner Court) is a complex of buildings. It houses the meeting place of both houses of the State's General of the Netherlands, as well as the Ministry of General Affairs and the office of the Prime Minister of the Netherlands. Built primarily in the 13^{th} century, the Gothic castle originally functioned as residence of the counts of Holland and became the political centre of the Dutch Republic in 1584. The *Binnenhof* is the oldest House of Parliament in the world still in use. The Prime Minister's office, which is located in the small tower in the northern corner, is simply called the Torentje ("Little Tower"). As a spot for governance, rulling, and hidden political plots, you have to coordinate yourselves in secret to succeed. You will be blindfolded, given a secret individual number, and you will then have to line up in numerical order WITHOUT TALKING (you have other ways to communicate :)).

- Challenge 5 ("**The Prisoner's Gate**"): The *Gevangenpoort* (Prisoner's Gate) is a former gate and medieval prison. From 1420 until 1828, the prison was used for housing people who had committed serious crimes while they awaited sentencing. Its most famous prisoner was Cornelis de Witt, who was held on the charge of plotting the murder of the *stadtholder*. As all prisoners have to play with all the entanglements of the prison system to manage to escape, so will you. In order to complete the challenge and arrive to the restaurant as a united team, you need to untangle yourselves.

C

Supplementary material of case study in chapter 7: Challenges offered to participants as gaming activities

These are the challenges that stem from the co-design process followed previously to the case study reported in this study. Adolescents ideated 56 activities they would like to do in their neighbourhood (chapter 4.4), and in specific locations, which had to be adapted to the game. The challenges that ended up being played by the adolescents, per route, are detailed below, and cover all the different types of challenges (Athlete, Inventor, Detective, Explorer, Hunter, Artist, Volunteer, specified in the challenge framework of chapter 4). All routes have 2 challenges of each type, so that adolescents could play all types of challenges regardless of their route.

Route 1:

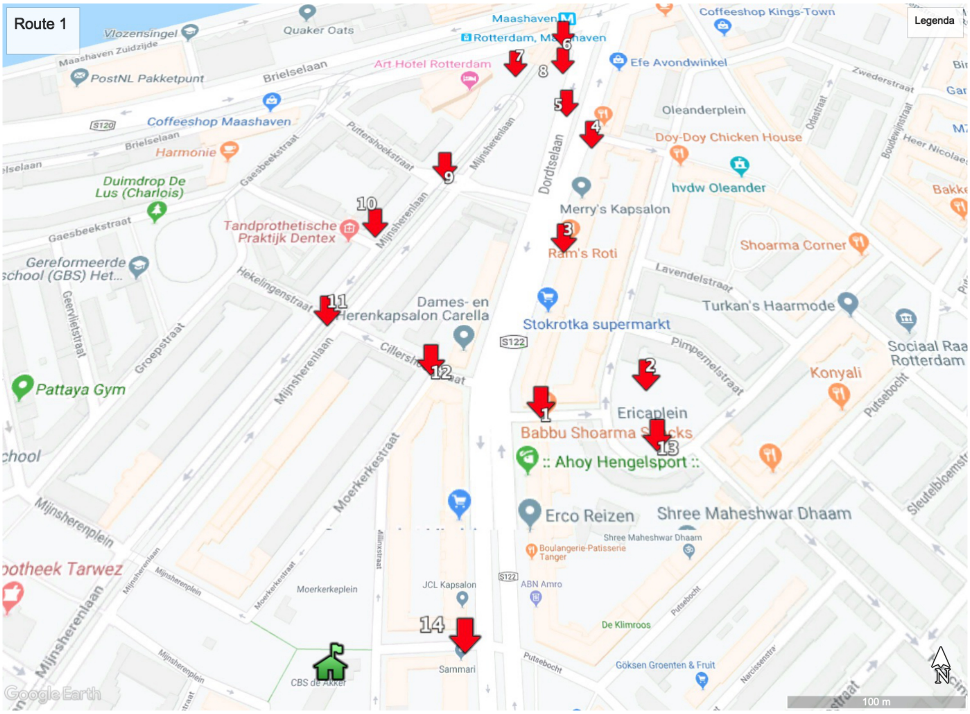


Figure C.1: The locations of the 14 challenges placed in Route 1. The icon greenhouse marks the school (starting and ending point), and the red arrows regard the positions of the challenges.

Challenge 1:	**Trash Paparazzi**
Type	Volunteer
Task	The municipality cleans up the streets. Citizens can report to the municipality when there is litter. Can you find some as well? Walk around and take a picture of trash.
Interaction	Collaboration

Challenge 2:	**Sprint Competition**
Type	Athlete
Task	On this square you can play. One thing you can do is running. Sprint from one side of the square to the other, who is the fastest?
Interaction	Supporting each other

Table C.1 (continued)

Challenge 3:	**Shopping Hunter (koopjes jager)**
Type	Hunter
Task	The Dordtselaan is one of the streets where people go shopping in this neighbourhood. Find one store you have never been before. Make a picture of it and upload them in the game.
Interaction	Discussion, talking about shops

Challenge 4:	**Endless Street**
Type	Detective
Task	Answer the question: How long is the Dordtselaan?
Interaction	Asking somebody on the street, discussion

Challenge 5:	**Rap Performer**
Type	Artist
Task	Many people in this neighbourhood like music, especially rap songs. Make a short rap of 6 sentences about what you can do at the Dordtselaan.
Interaction	Discussion, creating a rap together

Challenge 6:	**Travel the other way**
Type	Hunter
Task	Challenge as much people as possible what other transportation mean they could use to travel around. (Participants need to talk to as many people as they can in 3 minutes, and write in the game how many people they talked to)
Interaction	Approaching strangers, talking to them

Challenge 7:	**Some more light please ...**
Type	Inventor
Task	This location is quite dark and not very nice to be around. Can you make a plan to increase the amount of lights for this location? Where would you place the lights and what kind of lights? (They can use pen + paper for this and make a picture and upload that into the game)
Interaction	Discussion, creating a plan together

C

Table C.1 (continued)

Challenge 8:	**Neighbourhood statue**
Type	Inventor
Task	Many people frequent here every day. Make a design of a statue of the people who live here and upload a picture of your drawing. (They can use pen + paper for this and make a picture and upload that into the game)
Interaction	Discussion, drawing together

Challenge 9:	**Street names**
Type	Artist
Task	Do you know what the meaning of the streets names is here? Maybe you can come up with nicer ones! Come up with new street names for this location.
Interaction	Discussion, coming up with ideas

Challenge 10:	**Can you translate?**
Type	Explorer
Task	Many languages are spoken here. Choose a word and translate it into 5 languages.
Interaction	Asking people on the street, discussion

Challenge 11:	**Passing along**
Type	Detective
Task	Answer the question: How many metros pass by each day?
Interaction	Asking people on the street, discussion

Challenge 12:	**Metro users**
Type	Explorer
Task	Many people use the metro to go to work or other meetings. Find within 1 minute 10 people that use the metro
Interaction	Asking people on the street

Challenge 13:	**Scoring**
Type	Athlete

Table C.1 (continued)

Task	You can play football at this square. How many goals can you make in one minute? (a tennis ball is handed out to the group)
Interaction	Supporting each other in the physical play

Challenge 14:	**Helping out**
Type	Volunteer
Task	People are doing their grocery shopping here. Can you help them with that? Be a nice neighbour and offer someone to carry their bag for 20 m.
Interaction	Helping someone, asking a question

Table C.1: Challenges of Route 1.

***Route 2*:**

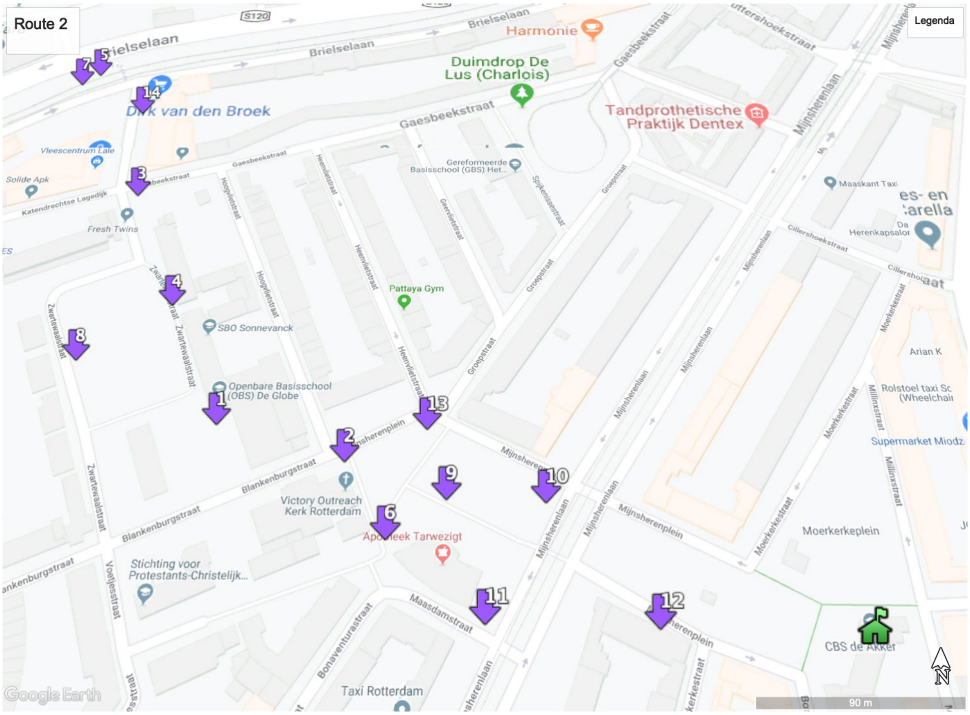


Figure C.2: The locations of the 14 challenges placed in Route 2. The icon greenhouse marks the school (starting and ending point), and the purple arrows regard the positions of the challenges.

Challenge 1:	**School's out!**

Table C.2 (continued)

Type	Detective
Task	Answer the question: How long does the school exist?
Interaction	Asking somebody from the school

Challenge 2:	**Schools around**
Type	Explorer
Task	This neighbourhood is characterised by the amount of schools. Find one other schools around here (De Akker dependence, GBS Het Kompas, Elout van Soeterwoude School are close - 5min walking max)
Interaction	Asking people who pass by, discussion in the team

Challenge 3:	**Street names**
Type	Artist
Task	The street names here correspond to towns around Rotterdam. Maybe you can come up with nicer names! Come up with new street names for this location.
Interaction	Discussion, coming up with ideas

Challenge 4:	**Neighbourhood statue**
Type	Inventor
Task	Many different people live in this neighbourhood, from many countries. Make a design of a statue of the people who live here and upload a picture of your drawing. (They can use pen + paper for this and make a picture and upload that into the game)
Interaction	Discussion, coming up with ideas

Challenge 5:	**Rap Performer**
Type	Artist
Task	Many people in this neighbourhood like music, especially rap songs. Make a short rap of 6 sentences about what you see around here.
Interaction	Discussion, creating a rap together

Challenge 6:	**Trash Paparazzi**
Type	Volunteer

Table C.2 (continued)

Task	The municipality cleans up the streets. Citizens can report to the municipality when there is litter. Can you find some as well? Walk around and take a picture of trash.
Interaction	Collaboration

Challenge 7:	**Tarwewijk**
Type	Detective
Task	The factory you see here (Meneba) produces wheat. Come up with 5 products that contain wheat.
Interaction	Discussion, asking people on the street

Challenge 8:	**Some more light please ...**
Type	Inventor
Task	This location is quite dark and not very nice to be around. Can you make a plan to increase the amount of lights for this location? Where would you place the lights and what kind of lights? (They can use pen + paper for this and make a picture and upload that into the game)
Interaction	Discussion, creating a plan together

Challenge 9:	**Miscommunication**
Type	Athlete
Task	People here speak many different languages. Sometimes you do not understand each other. Try to play a game together without speaking to each other, to experience how you still can communicate when you are not speaking the same language (look for objects to play with).
Interaction	Discussion, touching

Challenge 10:	**Sprint competition**
Type	Athlete
Task	On this square you can play. One thing you can do is running. Sprint from one side of the square to the other, who is the fastest?
Interaction	Supporting each other

Challenge 11:	**Spot the cars**
Type	Hunter

Table C.2 (continued)

Task	Many cars are parked here, and drive around. They have registration plates from different countries. How many white registration plates can you spot in one minute?
Interaction	Discussion

Challenge 12:	**Languages in the neighbourhood**
Type	Explorer
Task	People speak many different languages here. Can you find at least 8 languages spoken in this neighbourhood? You can discuss in the team or ask people on the street which languages they speak!
Interaction	Discussion, listening to people speaking, asking questions

Challenge 13:	**Bring me some flowers**
Type	Hunter
Task	The neighbourhood has many nice places. Make a picture of flowers that are put in front of someoneâĂŹs doorstep.
Interaction	Discussion

Challenge 14:	**Helping out**
Type	Volunteer
Task	People are doing their grocery shopping here. Can you help them with that? Be a nice neighbour and offer someone to carry their bag for 20 m.
Interaction	Helping someone, asking a question

Table C.2: Challenges of Route 2.

Route 3:

Figure C.3: The locations of the 14 challenges placed in Route 3. The icon greenhouse marks the school (starting and ending point), and the lime green arrows regard the positions of the challenges.

Challenge 1:	**Rap Performer**
Type	Artist
Task	Many people in this neighbourhood like music, especially rap songs. Make a short rap of 6 sentences about what you see around here.
Interaction	Discussion, creating a rap together

Challenge 2:	**Origin of Feyenoord**
Type	Hunter
Task	Feyenoord has its origin in this neighbourhood. You can find tiles around of players that used to live here. Find the tile of Feyenoord player Henk Duut.
Interaction	Asking people who pass by, discussion in the team

Table C.3 (continued)

Challenge 3:	**Some more light please ...**
Type	Inventor
Task	This location is quite dark and not very nice to be around. Can you make a plan to increase the amount of lights for this location? Where would you place the lights and what kind of lights? (They can use pen + paper for this and make a picture and upload that into the game)
Interaction	Discussion, creating a plan together

Challenge 4:	**Tall buildings**
Type	Detective
Task	Answer the question: How high are the apartments? (Adolescents need to make an estimation)
Interaction	Discussion, asking people who pass by

Challenge 5:	**Wave the flag**
Type	Detective
Task	Answer the question: Which flags hang here? (Answer: Brandweer and Rotterdam)
Interaction	Discussion, asking people who pass by

Challenge 6:	**Eating at Zuidplein**
Type	Explorer
Task	Zuidplein is a central place in the neighbourhood, many citizens go there a lot to eat. Find three restaurants that serve different types of food at Zuidplein.
Interaction	Discussion

Challenge 7:	**Neighbourhood statue**
Type	Inventor
Task	Many people frequent here every day. Make a design of a statue of the people who live here and upload a picture of your drawing. (They can use pen + paper for this and make a picture and upload that into the game)
Interaction	Discussion, drawing together

Table C.3 (continued)

Challenge 8:	**What do you do?**
Type	Explorer
Task	Zuidplein is visited by many people from this neighbourhood. Interview people what they do at Zuidplein, to get to know more about this place. You have 3 minutes.
Interaction	Talking with strangers, asking questions

Challenge 9:	**Street names**
Type	Artist
Task	Do you know what the meaning of the streets names is here? Maybe you can come up with nicer ones! Come up with new street names for this location.
Interaction	Discussion, coming up with ideas

Challenge 10:	**Scoring**
Type	Athlete
Task	You can play football at this square. How many goals can you make in one minute?
Interaction	Supporting each other

Challenge 11:	**Who is the fastest?**
Type	Athlete
Task	This playground offers a parkour. How fast can you do the parkour?
Interaction	Supporting each other

Challenge 12:	**Trash Paparazzi**
Type	Volunteer
Task	The municipality cleans up the streets. Citizens can report to the municipality when there is litter. Can you find some as well? Walk around and take a picture of trash.
Interaction	Collaboration

Challenge 13:	**Find recommendations**
Type	Hunter

Table C.3 (continued)

Task	The community centre is a central place for youngsters, adolescents and adults of the neighbourhood. Talk to volunteers of the community centre to ask recommendations on activities that you can do here.
Interaction	Talking to representatives of the community centre, asking questions

Challenge 14:	**Helping out**
Type	Volunteer
Task	People are doing their grocery shopping here. Can you help them with that? Be a nice neighbour and offer someone to carry their bag for 20 m.
Interaction	Helping someone, asking a question

Table C.3: Challenges of Route 3.

D

10.4 Supplementary material specific to the Secrets of the South game, described in chapter 6

This appendix covers in detail the technology used by the Secrets of the South (SotS), the functional requirements behind the implementation done, and the workings of the implemented game throughout activity diagrams. Instructions on retrieving the complete source code of the Secrets of the South, setting it up, and creating players can be found online at https://github.com/xav13rua/SecretsOfTheSouth.

D.1. Technology Used

The SotS game framework's architecture is comprised of several components, regarding the mobile game application (the actual game) and its supporting IT system (the several systems). Players can experience the SotS game mainly by playing the SotS mobile application. Additionally, they can also go to the participatory system online (via a web browser), to get to know the project, learn the location of challenges put all around the world, and take part of this initiative by creating their own. The mobile application connects to the SotS game framework over the internet. Given that this is a pervasive mobile game, this connection is ideally established over the phone's carrier (3G, 4G, or 5G), but WIFI is also allowed. During the game play of the SotS, three components are involved: 1) the Microsoft Azure Playfab™© backend platform, 2) the SotS custom online system created by the researchers, and 3) the Mapbox™© servers. In the component 1), it is stored the user accounts that the mobile application uses to log the player into the game. It also stored some play statistics provided by Playfab, such as how many players logged into the application, and how many API calls the game did to the Playfab server. Component 2) manages the entire content of the challenges that the game provides. The mobile game sends its location to this server, and based on the preferences of the player (e.g. to be seeing challenges up to 1 kilometre), this server replies with the list of challenges surrounding the player. The SotS custom system logs any event resultant from the game play (e.g. challenges opened, solved, QR codes of other players scanned, teams created and joined, and the position of the player per each 5 seconds). It also records the user accounts for the access to the participatory system, used for players to take an active contribution role and create/manage their challenges. Component 3) regards the Mapbox commercial service provider, a large provider of custom online maps for websites and applications that is based on open data sources (e.g. OpenStreetMap). In terms of technologies used, the SotS mobile application is built under the Unity™© game engine ecosystem[1]. The game is built and deployed for the Android™© mobile operating system, more specifically for the Android versions between 5.0 (coded 'Lollipop', API version 21) and 6.0 (coded 'Marshmallow', API version 23). Recommended hardware specifications to run the game are 1.5GB memory RAM, camera, GPS sensor, touch screen, and 4G-based data plan. The Mapbox service provides data on 3D maps and 3D buildings, and is directly attached to the mobile application through the Unity game engine. Regarding the SotS custom server, the MeteorJS[2]™© JavaScript web framework is used for the information system, and MongoDB[3] for the persistency layer of the information system. MeteorJS is chosen as a free open-source full stack platform to enable the creation of cross-platform javascript-based applications (web, mobile, and desktop). It uses a publish-subscribe distributed data model for real-time data propagation between the server and the web clients linked to the server, and offers straightforward integration with MongoDB to store the data of the application. MongoDB is thus used, a NoSQL cross-platform document-oriented database. It is a non-relational database that is designed to be distributed and for the cloud. Lastly, the Playfab server is a web-based provider of services for games, a backend platform that enables developers to support their cloud-based games often based on multiplayer features, and with geolocation and latency requirements. This platform is capable of supporting games regardless of the ecosystem they were built in, and aims at both accelerating the development phase, and supporting the games that aim at scaling up at later stages.

D.2. FUNCTIONAL REQUIREMENTS AND THEIR IMPLEMENTATION

Throughout the development period of the SotS, functional requirements are created. The complete list of functional requirements that led to the implementation of the SotS location-based game are detailed below, and are a translation of everything that was successfully captured from users, and required functionality that had to be implemented for the workshops to be executed. These are coded, and each code is then used to detail how they were addressed in the implemented prototype of the SotS (tables D.1 to D.4).

List of Functional requirements:

A. The game is based on challenges or activities

[1] https://unity3d.com/, Unity3D for all, last visited on December 23, 2020.
[2] https://www.meteor.com/, The fastest way to build JavaScript APPS, last visited on December 23, 2020.
[3] https://www.mongodb.com/, The database for modern applications, last visited on December 23, 2020.

1. Challenges need to be stored
   i. In a structured way
      1. Challenges must be unique
      2. Be described in plain language
      3. Be associated to a real-wold location (both in terms of coordinates, and the social context it is placed in)
      4. Have the possibility to be unique to specific routes
      5. Involve different actions from players to be solved
   ii. Challenges have a specific structure per type of action required
      1. Challenges have to ask closed questions and have closed answers
      2. Challenges have to ask open questions
      3. Challenges have to ask tasks
         a. To players
         b. To groups of players
         c. To search for items in the real world
         d. That have to be solved within a time frame
         e. That require pictures to be taken
         f. That allow players to vote/rank other players' solutions
         g. And offer an alternative way to be solved in case the task in the real world is not solvable at that point in time
   iii. Answers to challenges that are prone to be voted/ranked have to be stored
      1. Challenges have a list of solutions given
      2. The solutions have to be stored in a structured way
         a. Be associated to a challenge
         b. Have the unique identification of the player who published the solution
         c. Have the public name of the author to be shown to other players, given by the player
      3. Each solution needs to store the votes/ranks received
         a. Each solution has a list of all the votes/ranks received
         b. Each vote/rank given contains:
            i. the player's unique ID
            ii. the vote/rank given
      4. Votes/Ranks need to be stored through a public API
         a. Based on a challenge ID
         b. Based on a the player's unique ID
         c. Based on the vote/rank to be stored
2. Challenges need to be retrieved

i. Challenges must be retrievable regardless of specific implementations from the client applications
    1. Challenges must have a public API where client applications can consume them
    2. Public API must be based on open web standards for maximisation of interoperability

ii. Solutions given by players that are prone to be voted/ranked need to be retrievable
    1. Based on a public API
    2. Based on unique identification of challenge

iii. A single challenge needs to be retrievable
    1. Based on unique identification of challenge

iv. A list of challenges needs to be retrievable at once
    1. Based on location in the real world (coordinates)

3. Challenges must be managed via an online Content Management System (CMS)

    i. The CMS has to have users with different permissions
        1. Users
            a. Create their own challenges
            b. Manage their own challenges
        2. One administrator
            a. Create its own challenges
            b. Manage its own challenges
            c. Manage all the users' challenges

    ii. The CMS has to enforce that only registered users can create/manage challenges
        1. Log in mechanism
        2. Account creation, either by anyone, or the administrator only

B. Game needs to promote exploration of the real world physical space

1. Challenges are placed at a real world location

    i. The location is composed by real world coordinates

    ii. Challenges are layered on top of a map
        1. The map is a digital map that represents the real-world
        2. The challenges are represented by digital icons

2. Challenges must be found by players

    i. Players must see the challenges surrounding them
        1. Via a list of challenges

a. The list of challenges shows the distance between each challenge and the player
b. Each challenge in the list shows the direction the player needs to take to find it
2. Via icons on the digital map

ii. Players must have a mechanism that assists them in the navigation
1. Mechanism needs to update in real-time
2. Mechanism needs to inform players on their orientation

3. Exploration and navigation must be based on location-based services or technology
i. Mobile application must use the global positioning system (GPS)
ii. Provided location must be fine-grained
iii. Provided location must be updated with a frequent and regular interval

D

C. Game needs to provide mechanisms for interaction, dynamics of competition and collaboration, manage players, provide statistics to players, and a form to represent players

1. Game has to react to physical encounters with people, by adding to player's statistics the number of:
i. Physical encounters between players
ii. Physical encounters between a player and non-players
iii. Physical encounters between a player and a team of players
iv. People that a player engages with during a challenge

2. Game has to react to the physical environment
i. Navigation stops when the player is in close proximity to the navigated challenge
ii. Items found in the real world have to advance the game play of the player
1. Challenges need to be solved when certain items are found
a. Solving challenges attributes statistics to player
2. Players interact with challenges when certain items are found
3. Players can observe other players' solutions of a challenge
4. Players can vote/rank other players' solutions of a challenge

3. Game needs different dynamics of game play
i. Game needs collaboration
1. A player needs to create a group of players
2. A player has to be able to join a group of players
3. Groups of players have to be ranked
a. Based on their performance

      b. Based on the number of challenges they solved
    4. A player acting as evaluator has to rank the performance of a team
    5. A player has to be able to collaborate with another to scan (or be scanned)
      a. Both players earn points
  ii. Game needs competition
    1. Game needs a leader board for the amount of interactions with other people
    2. Game needs a leader board for the best performing teams
      a. An external player has to rate these performances and add them to the system
    3. Game needs to distinguish the performance of players
      a. Total points for correct answers, less points for incorrect or incomplete answers
      b. Points in proportion to the amount of people that players engaged with, during a challenge

4. Game needs to provide statistics for the player's game play
  i. Number of people met
  ii. Number of challenges solved
  iii. Number of challenges created by the player in the CMS
  iv. Number of challenges that were solved first by this player up to that point in time
  v. Quantity of Gold (linked to how many challenges were solved, and people engaged)

5. Game needs to manage players
  i. Game play, and players, need to be managed
    1. Unique player accounts need to be created and managed
      a. In a centralised way, online
      b. By the game administrator
    2. Game play needs to be tracked
      a. Statistics of game play, and leader boards need to be accessible
        i. Accessible online
        ii. Accessible to the game administrator
      b. Leader boards of the game need to be stored online
      c. Leader boards need to be managed by the game administrator
      d. Any global variables instrumental to the game play needs to be stored online and accessible to all players at the same time
      e. These global variables must prevent points being added twice for the same event
  ii. Players need to have different roles in the game
    1. Players can have no special role, and simply play the game

2. Players can be evaluators of the performance of a group of players solving a challenge
3. Players can be administrators and manage the roles of other players for the game play

iii. Roles in the game need to be dynamic
1. A role of a player needs to be elevated from no special role to evaluator or administrator
2. A role of a player needs to be demoted from administrator to evaluator or no special role
3. Roles can be changed during game play by administrators

iv. Game play needs to be able to react to a change in the player's role
1. Players have to be able to see the different options of their current role in the game

6. The game needs to provide a visual representation of players
i. This visual representation has to be seen during the game play
ii. This visual representation has to be customise
1. By the player
2. By the administrator

D. Game needs to collect data throughout the game play, and automatically log important events online

1. Encounters with other people
2. Items scanned in the environment
3. Challenges opened
4. Challenges solved
5. Player saw the solutions posted in a given challenge
6. Votes/ranks of solutions given
7. Last known location of the player
8. Teams formed

Implementation of the functional requirements A:

Req.	Implementation in the SotS game framework
A.1.i	• It is implemented an online database (MongoDB), where challenges are stored in a structured and non-relational way
A.1.i.1	• Challenges have an ID field
A.1.i.2	• Challenges have a title, and a description • Challenges are written in different languages • Challenges have a question, answer, or task

Table D.1 (continued)

A.1.i.3	• Challenges have a latitude and longitude tuple
A.1.i.4	• Challenges have a field for the route. Possible values are 0, 1, 2, and 3. The value 0 is the default value, and means no route has been specified
A.1.i.5	• It is implemented different types of challenges in the game • Each type involves different actions from players: taking pictures, do a task within a time frame, search for specific people in the neighbourhood to find an answer, solve a challenge by scanning a QR code hidden in the neighbourhood, or provide an (open) answer
A.1.ii.1	• Challenges type Quiz implement this
A.1.ii.2	• Challenges type Open Quiz implement this
A.1.ii.3.a	• Challenges of type Quiz, Open Quiz, Hunter, Voting, and Timed Task, implement this
A.1.ii.1.b	• Challenges of type Multiplayer implement this. Players have to form a team first, to open them.
A.1.ii.1.c	• Challenges of type Hunter can be solved by having players scanning a QR code in the environment
A.1.ii.1.d	• Challenges of type Timed Task implement a countdown timer
A.1.ii.1.e	• Challenges of type Voting are solved by taking a picture and uploading it into the challenge
A.1.ii.1.f	• Challenges of type Voting allow players to see other players' pictures uploaded into the challenge before this player. Player can only see these after uploading a picture first. Once this option is available, players can vote on other players' solutions (not on their own solution)
A.1.ii.1.g	• Challenges of Type Hunter ask a closed question and expect a closed answer. However, they offer the possibility of being solved by having players scanning a QR code linked to that challenge
A.1.iii.1	• Pictures of the Voting challenges are stored in the hard drive of the SotS Custom System. Every picture under the voting-specific challenge ID can be listed.
A.1.iii.2 A.1.iii.2.a A.1.iii.2.b A.1.iii.2.c	• Pictures of the Voting challenges are stored in the hard drive of the SotS Custom System with the following schema: *~/PathOfVotingChallengesFolder/challengeID/playerID_authorName.png*. Example: *~/PathOfVotingChallengesFolder/2Mouvy9/78B299F0_John.png*

Table D.1 (continued)

A.1.iii.3 A.1.iii.3.a A.1.iii.3.b A.1.iii.3.b.i A.1.iii.3.b.ii	• The list of votes that each picture has is stored in the database. Votes stored in the database contain the player id, the total number of votes given, and the distribution of votes between 0 and 5 stars. Example: E1A7E9823E8C41CB_2_0_0_1_0_2_1_3_1_4_0_5_0, where "E1A7E9823E8C41CB" is the playerID, the first number following the playerID is the total number of votes received (2 votes in this example), and the following sequence specifies where these votes were given. In this case, one vote for 2 stars, and one for 3 stars.
A.1.iii.4 A.1.iii.4.a A.1.iii.4.b A.1.iii.4.c	• An API is provided. Example: Website/api/voteonvotingchallenge?challengeid=2Mouvy9&playfabID=78B299F0&vote=2 Where *2Mouvy9* is the challenge ID, 78B299F0 the player that posted a solution to this challenge, and 2 the vote given by the current player to the identified player
A.2.i A.2.i.1 A.2.i.2	• The SotS Custom System provides with a public set of APIs that send information in JSON, an open-standard file format capable of sending data and data streams.
A.2.ii A.2.ii.1 A.2.ii.2 A.2.iii A.2.iii.1	• Same as functional requirement A.1.iii.3. API built communicates based on JSON format: *Website/api/challenges_voting?id=challengeID*, E.g.: http://secretsofthesouth.tbm.tudelft.nl/api/challenges_voting?id=Kj8rcMQiwyJZm8rCG
A.2.iv A.2.iv.1	• API built to retrieve a list of challenges based on a tuple of latitude and longitude: Website/api/challengesnearby?maxDistanceFromPlayer=A&playerLat=B&playerLng=C, where A is the radius in kilometres, B is the latitude of the player, and C the longitude.
A.3	• The SotS game framework provides the component "SotS Custom System" that acts as CMS
A.3.i A.3.i.1 A.3.i.1.a A.3.i.1.b A.3.i.2 A.3.i.2.a A.3.i.2.b A.3.i.2.c A.3.ii A.3.ii.1 A.3.ii.2	• The SotS Custom System implements this.

Table D.1: Functional requirements A, and how these are implemented in the SotS game framework.

Implementation of the functional requirements B:

Req.	Implementation in the SotS game framework
B.1 B.1.i	• All the challenges that the game provides are based on a real-world location, represented by a tuple latitude/longitude
B.1.ii B.1.ii.1	• The game offers a service for 3D maps, implemented in the mobile application with an addon from Mapbox service provider. • This service provides a map based on the provided location (in this case, of the player), and sends the map divided into "tiles". The mobile application loads these tiles and renders them in the game environment. • This service also provides 3D information of the buildings surrounding the player
B.1.ii.2	• Together with the map and the buildings, the mobile application also renders 3D icons on the map, which represent the challenges. As challenges have different types and make players do different actions in the game, these 3D icons vary
B.2.i	• The game displays the location of the player on the map (with a 3D character), and surrounds it with the 3D icons representing the challenges.
B.2.i.1 B.2.i.1.a B.2.i.1.b B.2.i.2	• The mobile application implements this.
B.2.ii B.2.ii.1 B.2.ii.2	• The mobile application provides players with a 3D compass to guide them in the direction of a selected challenge. The orientation of the player is implemented between the camera view of the game and the direction set between the player's location and the challenge. Based on this offset, the compass turns to the direction where the camera view should face. • It is also shown a text message in the middle of the screen saying how many meters are left, between the player and the selected challenge. • Both the compass and the text message are updated in real-time.
B.3 B.3.i	• The SotS mobile application is based on the GPS receiver from the smartphone, and this is supported by the network location services (A-GPS) that the smartphone has access to
B.3.ii B.3.iii	• The mobile application uses the most accurate positioning system available to the smartphone, and updates the coordinates each second.

Table D.2: Functional requirements B, and how these are implemented in the SotS game framework.

Implementation of the functional requirements C:

Req.	Implementation in the SotS game framework
C.1 C.1.i C.1.ii C.1.iii	• The SotS mobile application has implemented a mechanism of interaction based on QR codes, and a QR code scanner. This scanner is able to distinguish the different types of QR codes offered by the game. • When a player scans another player, the game counts this interaction under the "people met" statistic • When a player scans a team's QR code, the player joins that team • The game also allows the creation of QR codes to be printed and hand given to people not actively playing the game through the mobile application. These are also counted by the game under the "people met" statistic
C.1.iv	• Challenges of type Timed Task have implemented a follow up question, in the format "How many people did you ...?". Players can then introduce how many people they engaged with on the street, and this number is then added on top of the gold acquired by solving the challenge.
C.2 C.2.i	• During the navigation towards a challenge, both the text message and 3D compass disappear from the screen as soon as the location of the player is less than 50 meters away from the challenge
C.2.ii C.2.ii.1 C.2.ii.1.a	• The mobile application can scan QR codes left in the real world, and that correspond to specific challenges. • For challenges where players can solve them by finding a QR code, when the player scans these codes further information is shown in the game. This information is either text or images. At the same time, the challenge is visually marked as solved in the game, and the player gets gold as statistic.
C.2.ii.2 C.2.ii.3 C.2.ii.4	• For challenges where players can leave their solutions behind, a QR code can be scanned in the environment that is related to the challenge. This allows players to visit other players' solutions while not being near the challenge's location. • Scanning such code enables players to interact with the challenge (see its details, and solve it). After solving it, the player can see other players' solutions, and vote for them.
C.3.i C.3.i.1 C.3.i.2 C.3.i.3 C.3.i.3.a C.3.i.3.b C.3.i.5 C.3.i.5.a	• The mobile application, the SotS Custom System, and the Playfab components implement this. For statistics involving the leader board of people met, or points, the Playfab component is involved. The SotS Custom System is used to keep track of the statistics of the teams of players.

D

Table D.3 (continued)

C.3.i.4	• The mobile application offers different roles to players. One of them is the role evaluator. Players with this role can scan the QR code of a team, and rate their performance in the game.
C.3.ii.1 C.3.ii.2	• The mobile application implements this. For the requirement C.3.ii.1, the component Playfab server is involved, whereas for the C.3.ii.2, the SotS Custom Server is involved.
C.3.ii.2.a	• The role of evaluator in the mobile application is in charge of this.
C.3.ii.3.a C.3.ii.3.b	• The mobile application and the Playfab components implement this. The points attributed are in the statistic of gold.
C.4 C.4.i C.4.ii C.4.iv C.4.v	• The game provides this both as statistics in the mobile application (the player can see them), and in the Playfab server (the administrator can see and manage them).
C.4.iii	• This is observable in the mobile game. This statistic, unlike the others that are stored in the Playfab server, is stored in the SotS Custom System, given that it is there that the challenges are created.
C.5.i C.5.i.1 C.5.i.1.a C.5.i.1.b	• The Playfab server component is responsible entity for the accounts of the SotS mobile game. The administrator can create a new player there, and prepare a QR code for it to be used by the player of the game. With this QR code, the player can then log into the mobile application.
C.5.i.2 C.5.i.2.a C.5.i.2.a.i C.5.i.2.a.ii C.5.i.2.b C.5.i.2.c	• The Playfab server is also responsible for logging every connection that the mobile application makes to its server. As such, every time a player logs into the game, this information is shown to the game administrator in the Playfab server. This module also provides with a leader board for every statistic stored in this server (e.g. people met, or first to solve - challenges)
C.5.i.2.d C.5.i.2.e	• The Playfab server stores a set of global variables that contain information about both the challenges that players solved, and the players that a player already interacted with. • These global variables prevent a player to solve the same challenge twice and get double points. • These also prevent the same interaction with another player to be counted twice.
C.5.ii C.5.ii.1 C.5.ii.2 C.5.ii.3	• The game implements this, both in the mobile application and the SotS Custom Server.

D

Table D.3 (continued)

C.5.iii C.5.iii.1 C.5.iii.2 C.5.iii.3	• The mobile application presents an extra option for administrators in the menu, to manage the permissions that each player has. • An administrator can change these permissions in a convenient way, by scanning the player's QR code that h/she wants the permissions to change
C.5.iv C.5.iv.1	• In the mobile application, all players have access to an option to flush their permissions in the game. Also, every time a player enters the main menu, based on the options that appear on the left hand side, he can understand which function h/she got attributed
C.6 C.6.i C.6.ii.1	• Players can see their avatar in the mobile application, every time they enter the main menu. They can also use the web browser of the smartphone and acquire a URL of a different avatar. This can in turn be pasted under the settings of the game, and the new avatar is rendered in the menu of the application.
C.6.ii.2	• When the administrator creates an account in the Playfab server, h/she has the option to place a random or default URL for the player being created. • The administrator can also change this URL at any point in time.

Table D.3: Functional requirements C, and how these are implemented in the SotS game framework.

Implementation of the functional requirements D:

Req.	Implementation in the SotS game framework
D.1 D.2 D.3 D.4 D.5 D.6 D.7 D.8	• Implemented in the mobile application. • Every time a QR code is scanned via the mobile application, this event is stored in the SotS Custom System's database. • QR codes scanned in the real world are also logged.

Table D.4: Functional requirements D, and how these are implemented in the SotS game framework.

D.3. ACTIVITY DIAGRAMS

In order to document 1) the functionality of the several components of the SotS game framework, and 2) the processes between all the components of the framework, UML activity diagrams are used (Distilled, 2003). These diagrams show the activities allowed by the SotS game framework in a step-wise diagram, which help comprehend how the application works from the system and the player's point of view.

D.3.1. SotS Game Mobile Application

Figure D.1 shows the overall functionality of the SotS game, including everything that goes from the start-up of the application, to its termination. Figure D.2 details the options that players have when interacting with the main drop down menu of the game. Figure D.3 details the possible actions that players can do while solving the different types of challenges.

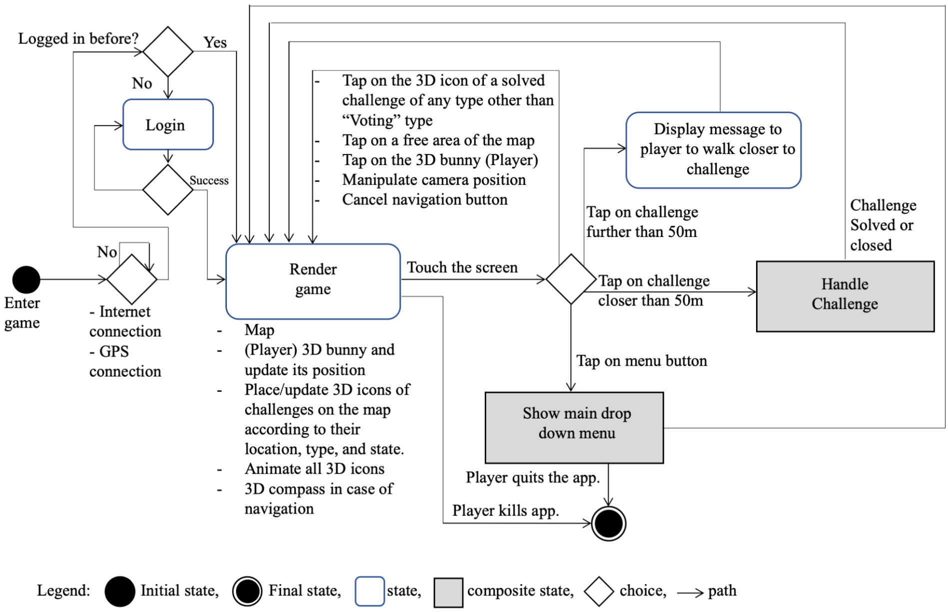


Figure D.1: SotS game overview activity diagram.

Figure D.1 shows that the SotS game starts by acquiring internet and GPS connections, without which the game cannot proceed. After a quick verification on whether the player has ever logged in before, the game either shows the login process (one that involves the players scanning a player QR code), or renders the 3D game environment (map, the player's bunny character, and all the 3D icons representing the buildings surrounding the player and the challenges). In this state ("Render Game"), the player can interact with the interface by touching on the screen, and this triggers different behaviour. If the player touches with one finger on the map and does not release the finger, the game begins to rotate around the player's character. Pinching in or out of the map makes the camera zoom in or out. Nothing happens if the player taps on the rabbit, on 3D icons representing challenges that were already solved (with an exception being the *Volunteer* type of challenge), or on the map and the buildings represented on it. To play the game, the player needs to solve challenges, and these can be accessed directly by tapping on unsolved challenges that are less than 50 meters away, or by navigating through the list of challenges found in the main drop down menu. Tapping on 3D icons of challenges that are further away will make the game display a message to the player saying to walk closer to open the challenge. The contrary will open a window revealing the challenge to the player. By selecting a challenge from the list of challenges in the menu, a 3D compass will be shown to the player, along with a message containing the remaining distance. This compass points in the direction of the challenge to be found, and will automatically disappear once the player is at a distance less than 50 meters. In this circumstance, the player can also tap a cancel button at the bottom of the game, which cancels the navigation and vanishes the compass and displayed message. The other way the player can interact with the game is by tapping on the drop down menu on the top-left corner. The application exits either through the menu, or by killing the application from the operating system.

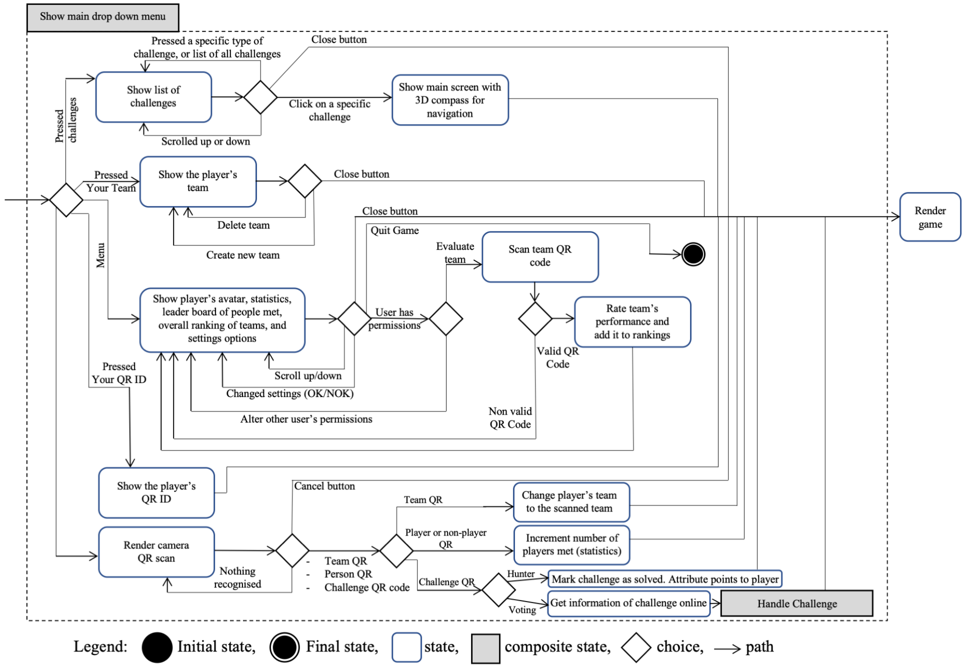


Figure D.2: Sub composite state "Show main drop down menu" activity diagram.

Figure D.2 shows the sub-actions that can be taken once the main drop down menu of the game is tapped on. This will reveal other sections of the game: the identification of the player in QR code, the team the player is in (if any), the list of challenges surrounding the player, the QR camera reader, and the menu. In the players QR ID, a QR code is shown containing the player's unique identification. In the player's team option, a sub-area appears where players can create their team, delete the team they are currently associated with (delete their association, not the actual team), or see the team's name, crest, and QR code of the team. In the list of challenges' option, a sub-area appears where all the challenges surrounding the player are shown. The challenges shown to the player are all within a certain configurable distance (standard 2 kilometres), and the player can select or filter challenges based on their type. Tapping on a challenge will reveal the main area of the game over layered with a 3D icon of a compass that indicates the direction of the selected challenge in real-time. Accessing the "Menu" option, players have access to a variety of options, which range from looking at the avatar they have and all their statistics, to the leader board of people met (where players can see where they stand with regard to all other players), the overall ranking of teams, and the settings options. In this menu, players can consult how well they and their team are doing in the game, and change the settings of the game (e.g. their avatar, distance of challenges preferred, and remove their account from the game). In case the player has elevated permissions (either as evaluator, or as administrator), extra options will appear under Menu. In such case, players can act as independent evaluators and evaluate a team's performance in *Multiplayer* type of challenges. For that, the player acting as evaluator can scan a team's QR code through this menu, and evaluate the team in aspects such as collaboration, participation of elements, and how much fun the team had in solving the challenge. If players have permissions as administrator, they can manage other player's permissions. Under the main drop down menu it can also be found a camera QR scan. This option will open the camera and allow the player to scan other player's QR ID code, team's QR codes, and QR codes left in the physical environment that are linked to a specific challenge. Scanning another player's QR ID will count this as "People Met" in the player's statistics. Scanning another player's team QR code will make the player join this team. Scanning a challenge QR code will mark that challenge as solved, while showing either text or picture referring to that challenge.

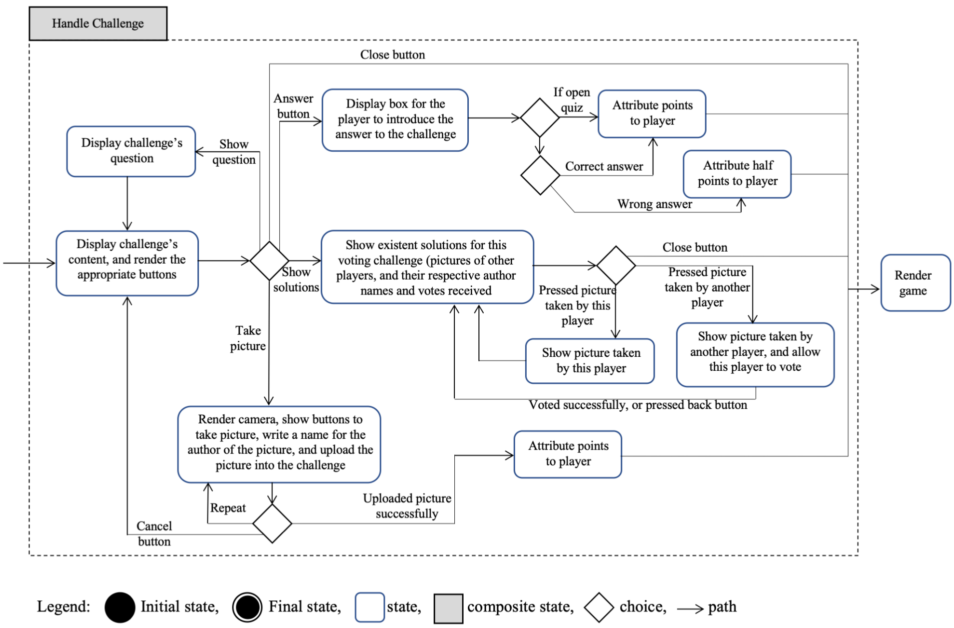


Figure D.3: Sub composite state "Handle challenge" activity diagram.

Figure D.3 shows the sub-actions that players can do when they interact with a challenge. When such interaction occurs, a window is shown with a title of the challenge, a picture, a general description of the challenge, and up to three buttons at the bottom, which vary based on the type of challenge being shown. *Quiz*, *Hunter*, and *Open Quiz* type of challenges reveal the buttons to show the question, introduce an answer, and close the window. *Multiplayer* challenges only show two buttons at the bottom: show task, and close the window. *Voting* challenge reveals 3 buttons: show question, take picture, and close window. The button take picture allows the player to snap a photo from the environment, attach an author's name, and attach it into that challenge in that specific location. After the successful post of the picture, the take picture button is replaced by show solutions button, meaning that the player cannot take other pictures, but see other player's pictures and their votes/ranks. The player can then tap on the picture of others, as leave a vote of 1 up to 5 stars. Is not possible to vote on the picture taken by the player itself. The last type of challenge is *Timed Task*, and it also shows 3 buttons at the bottom: show task, initiate countdown, and close window. In the second button, this challenge reveals a timer countdown that will show how much time players have to complete the challenge. At the end, this timer is replaced by a question that asks how successful the player was (e.g. "how many people did you talk to?"). Solving a challenge, or exiting the challenge window, will reveal the main window of the game again.

D

D.3.2. PARTICIPATORY SYSTEM, SOTS CUSTOM SERVER

Figure D.4 shows the activity diagram of the participatory system. When users enter the website, they are presented with two main pages, one giving an overview of the SotS game, and the other providing a more detailed background of the research project. From the main page, users can scroll down and click on a link to download the game from the Google Play store™©. Doing so will conduct players to a system that is outside the SotS participatory system. Users can also log into the system, provided that they have login credentials previously created by the administrator. With a successful login, users have access to a new area that is only reserved to authenticated users. This is also valid for administrators, that have access to another area and further functionality when compared to standard users. Regular users can consult all the challenges created for the SotS game: these are shown both on a list, and overlayered on a map. The challenges shown belong to everybody and are not from the user only. Users can scroll up and down the list of challenges, and can use it to access their own challenges and edit them (alter text, update picture's URL, and the location) or delete them.

They can also navigate the map presented on the page, zoom in and out from the location shown (which is Rotterdam by default), and become aware of the location of all the challenges put in the SotS game throughout the world. Users have the possibility to create a new challenge of one of 6 challenges types (*Quiz* - closed question, *Multiplayer* - task to be done by a group of players, *Hunter* - closed question with a possibility to solve the challenge with a QR code instead, *Voting* - take a picture of something and leaving it behind for others to rate it, *Open Quiz* - open question, and *Timed Task* - do a task within a time frame). Users can create a challenge, introduce the specific information required by each type of challenge, and submit it. When they do, an email is sent to the administrator of the participatory system to go online and verify that the challenge introduced matches the quality standards desired for the aimed play testing. If the user logged in has the permissions of administrator, h/she can manage any type of challenge (update, delete, activate or deactivate individual challenges), create challenges as if h/she were a regular user, and create a new

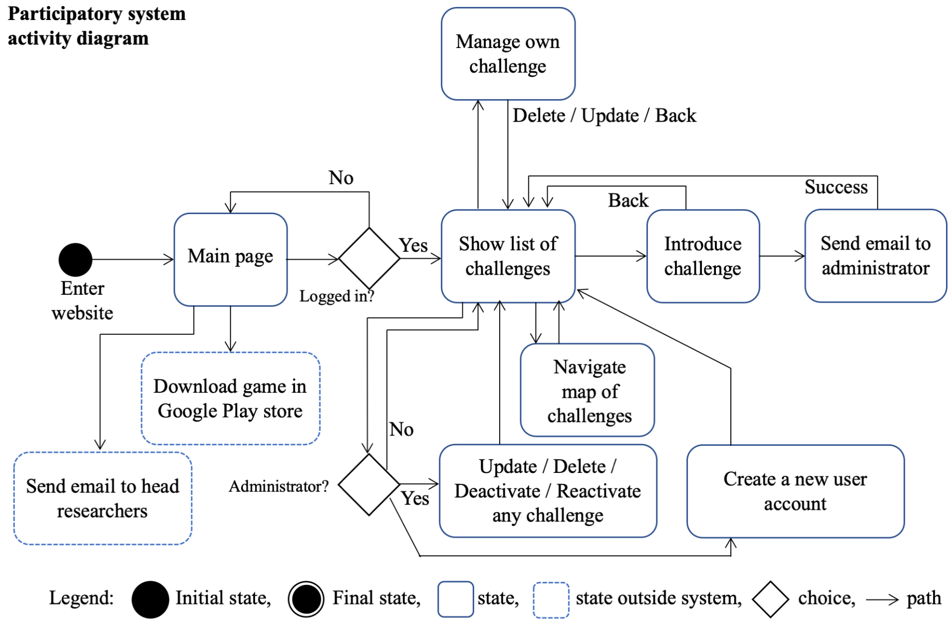


Figure D.4: Overview of the SotS participatory system, activity diagram.

user account for the participatory system.

D.3.3. CROSS-SYSTEM INTERACTION

The interaction between the different components of the SotS framework happens throughout the game, and can be divided into two types of situations: 1) QR code-based interaction between the player and other people or challenges presented in the system, and 2) automatic processes to sustain the game play. These are further detailed below through activity diagrams as well, which explain how the several components of the system are involved on a case basis.

A. QR code-based interaction

The SotS game is based on QR codes to keep track of the player's interaction with other players, with non-players that want to be actively involved in the game play of the game, and with the challenges of type *Hunter* and *Voting*.

Figure D.5 details the use case where the player encounters another player in the physical environment and both agree to scan the QR codes that identify them in the game. Beyond both players involved in this interaction, the Playfab server and the SotS custom server are involved as well. Since the Playfab server is the responsible component for user management and leader boards, this server counts up the interaction for both players in the "People Met" statistic, in case these players never scanned each other before (otherwise, this is ignored). Regardless, this encounter is logged in the SotS custom server.

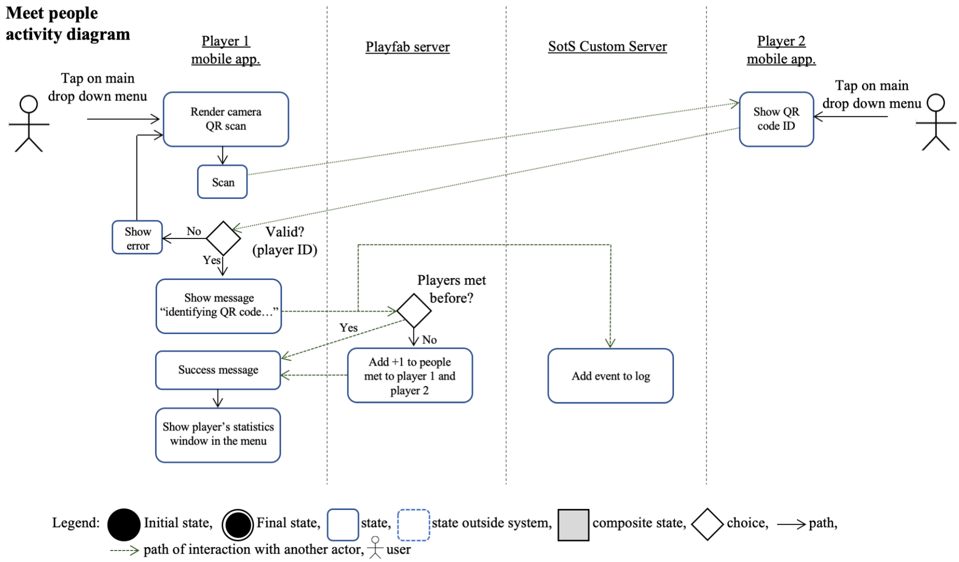


Figure D.5: Activity diagram of the case where the player scans another player's QR ID.

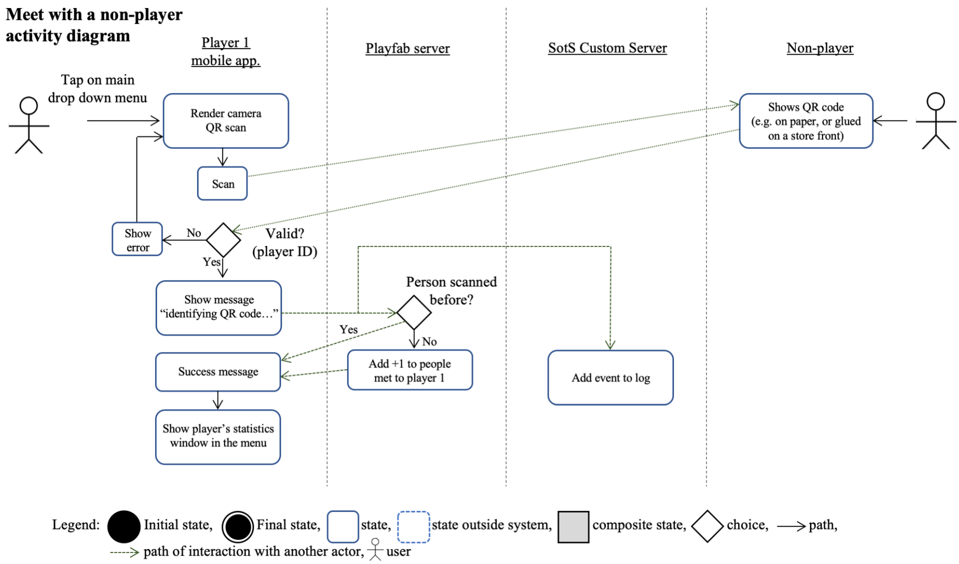


Figure D.6: Activity diagram of the case where the player scans a QR code that is printed outside the game.

Figure D.6 details the case where a player encounters a person not actively playing the game, but actively involved in a challenge (e.g. finding the owner of the shop at the corner). In this example, if the shop owner has a QR code of a non-player printed, h/she can be scanned by players and influence the counter of social interactions the game provides ("People Met"). The player meets the non-player, and while solving the challenge, the player asks to scan the QR code. Similarly to the previous case, both the Playfab and SotS custom servers are involved. The former counts the interaction if it was never registered before, and the later logs the interaction.

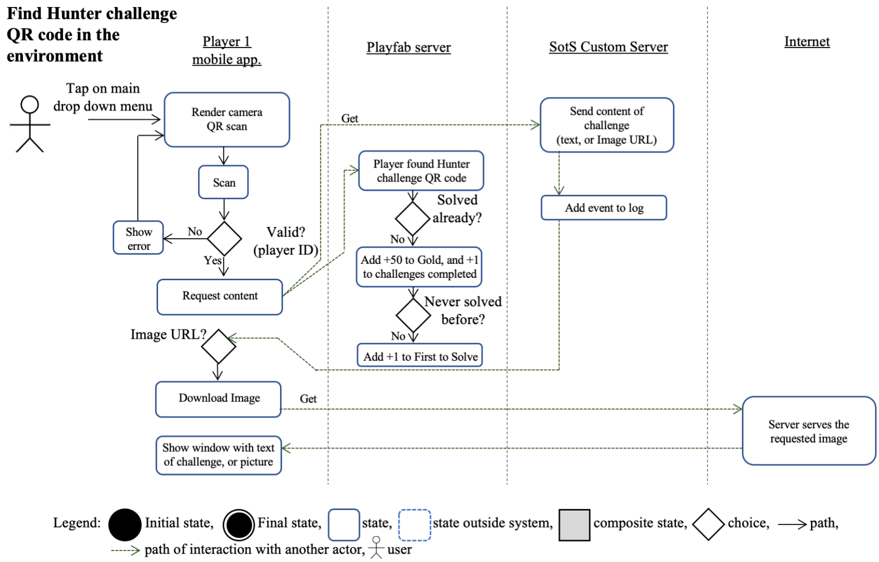


Figure D.7: Activity diagram of the case where the player scans a QR code belonging to a Hunter challenge.

Figure D.7 shows the case where the player is solving a *Hunter* challenge, and finds the QR code of that challenge in its physical surroundings. When such QR code is scanned, the challenge is marked as solved, the player gets the points for solving a challenge (if h/she never scanned this QR code), and reveals either a text or an image, belonging to that challenge. For this, the SotS game framework involves the player, the Playfab server, the SotS custom server, and the Internet (not part of this framework). The mobile application of the player scans the QR code, and requests the details of this challenge (either the text to be shown, or the image). This content (text, or image URL) are stored in the SotS custom system, as this information is part of the *Hunter* challenge stored there as well. When the mobile game receives the content, it requests the Playfab server to increment the player's statistics in the server, in case this player never solved this challenge (this is ignored otherwise). If the content that the mobile game received is text, it is immediately shown to the player. Otherwise, the game only has an image URL, and needs to download the actual image from the internet. In this process, the SotS custom server also logged this event.

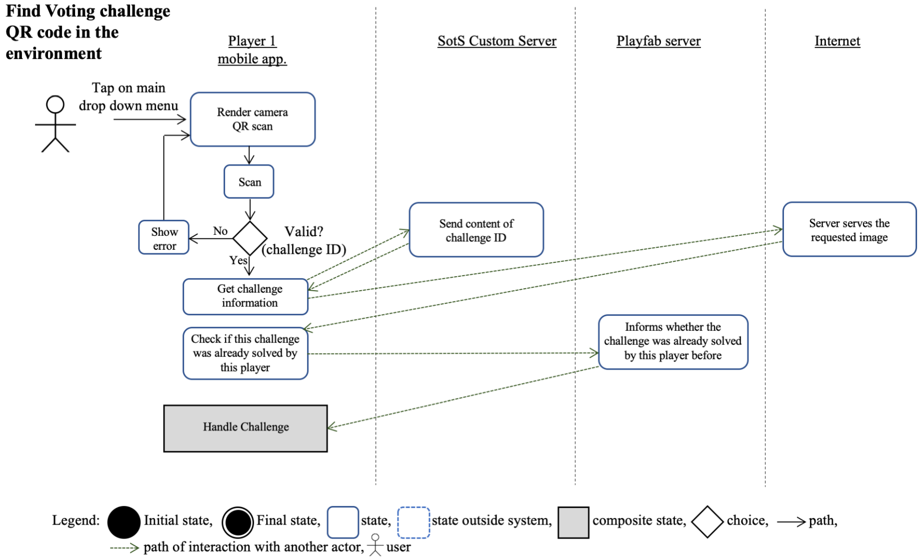


Figure D.8: Activity diagram of the case where the player scans a QR code belonging to a Voting challenge.

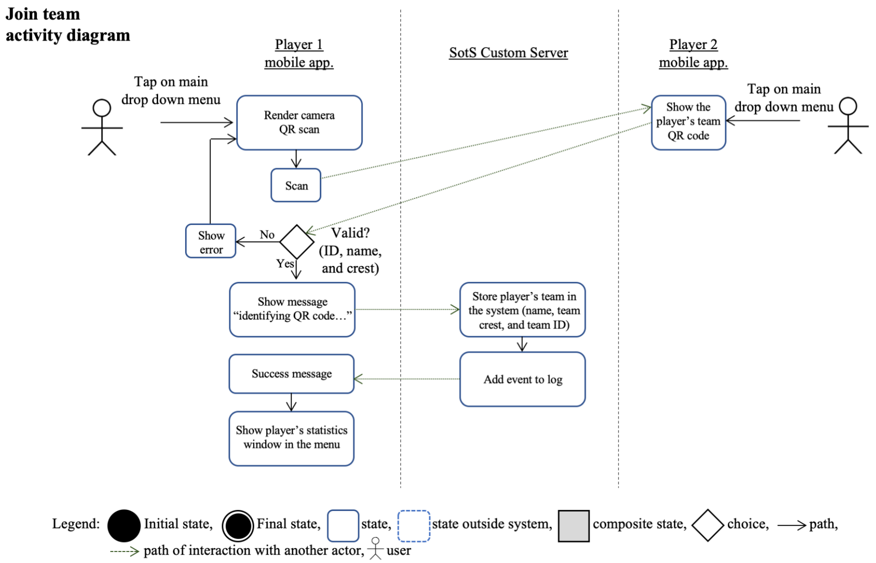


Figure D.9: Activity diagram of the case where the player scans another player's team QR.

Figure D.8 shows the case where the player is solving a *Voting* challenge, and finds the QR code of that challenge either in its physical surroundings, or that QR code is hand given by someone (e.g. a facilitator of a case study). When such QR code is scanned, the mobile application of the player contacts the SotS custom server to retrieve the entire content of that Voting challenge (title, image URL, description). From there, it retrieves the actual image of the image URL from the internet. Before rendering the window of the challenge to the player, the mobile application consults the Playfab server to understand whether the challenge was already solved by this player, which will influence the player's ability to publish a solution to this challenge or simply see and vote for other players' solutions. From here, the player has access to the window of the challenge, described by the sub composite state "Handle challenge" (Figure D.3).

Figure D.9 describes the case where the player (player 1) uses the mobile application to scan the team QR code from the mobile application of another player (player 2). When player 1 scans the QR code, the mobile application parses it to retrieve the team ID, team name, and the crest of the team. Then, the mobile application the SotS custom server that its new team is a different one, and stores these details in the server. The server also logs the fact that player 1 joined a new team. After this step, the mobile application shows the window of the team of player 1, with the duly updated new team.

B. Other cross-component interactions

Table D.5 summarises simpler, but still cross-component, interactions not based on QR code scanning. These cases support the entire game play, are initiated by the SotS mobile application, and trigger communication with all the other components of the SotS game framework:

Case	**Components Involved**	**Description**
Update surrounding map and objects	• Mapbox	The tiles of the 3D map, as we as the 3D buildings on the map, are downloaded by the mobile application.
(Re)Load challenges	• SotS custom server	The mobile game sends the player's coordinates (latitude, longitude), and the maximum distance desired for the challenges, and the SotS custom server replies with the list of challenges in JSON that match the criteria.
Update player status and leader boards	• Playfab • SotS custom server	The mobile game consults the Playfab server on a regular pre-defined amount time to update the player's set of statistics and the leader board of people met. The SotS custom server is consulted to retrieve the leader board of the team and their statistics (how many challenges each team solved, and the average ranking that evaluators gave).

Table D.5 (continued)

Log events	• SotS custom server	The mobile application registers meaningful events in the database inside the SotS custom server. These are registered only when they occur (e.g. player joined team, QR code scanned, challenge solved, challenge opened, challenge closed, and player met). It also stores the GPS location of the player on a regular basis (each 5 seconds).

Table D.5: Case-based processes throughout the SotS game framework.

BACK MATTER

Bibliography

Ahuja, M. K., & Carley, K. M. (1998). Network structure in virtual organizations. *Journal of computer-mediated communication*, *3*(4), JCMC343.

Ahuja, M. K., & Carley, K. M. (1999). Network structure in virtual organizations. *Organization Science*, *10*(6), 741–757.

Al Mahmud, A., Mubin, O., Shahid, S., & Martens, J.-B. (2010). Designing social games for children and older adults: Two related case studies. *Entertainment Computing*, *1*(3-4), 147–156.

Alaluf, M. (1999). Séminaire «evolutions démographiques et rôle de la protection sociale: Le concept de cohésion sociale». *Rapport final, Bruxelles, Centre de sociologie du travail, de l'emploi et de la formation de l'Université libre de Bruxelles et DGV, Commission européenne*, 16–17.

Aletta, F., Lepore, F., Kostara-Konstantinou, E., Kang, J., & Astolfi, A. (2016). An experimental study on the influence of soundscapes on people's behaviour in an open public space. *Applied sciences*, *6*(10), 276.

Alexander, J. T., Sear, J., & Oikonomou, A. (2013). An investigation of the effects of game difficulty on player enjoyment. *Entertainment computing*, *4*(1), 53–62.

Alvesson, M., & Skoldberg, K. (2009). Positivism, social constructionism, critical realism: Three reference points in the philosophy of science. *Reflexive methodology: New vistas for qualitative research*, 15–52.

Anderson, C. A. (2004). An update on the effects of playing violent video games. *Journal of adolescence*, *27*(1), 113–122.

Arango-López, J., Gallardo, J., Gutiérrez, F. L., Cerezo, E., Amengual, E., & Valera, R. (2017). Pervasive games: Giving a meaning based on the player experience, In *Proceedings of the xviii international conference on human computer interaction*.

Arrasvuori, J., Korhonen, H., & Väänänen-Vainio-Mattila, K. (2010). Exploring playfulness in user experience of personal mobile products, In *Proceedings of the 22nd conference of the computer-human interaction special interest group of australia on computer-human interaction*.

Asch, S. E. (1952). Group forces in the modification and distortion of judgments.

Avison, D., & Fitzgerald, G. (2003). *Information systems development: Methodologies, techniques and tools*. McGraw-Hill.

Avouris, N. M., & Yiannoutsou, N. (2012). A review of mobile location-based games for learning across physical and virtual spaces. *J. UCS*, *18*(15), 2120–2142.

Bailey, G. S. (1993). Iterative methodology and designer training in human-computer interface design, In *Proceedings of the interact'93 and chi'93 conference on human factors in computing systems*.

Ball, K., Cleland, V. J., Timperio, A. F., Salmon, J., Giles-Corti, B., & Crawford, D. A. (2010). Love thy neighbour? associations of social capital and crime with physical activity amongst women. *Social science & medicine*, *71*(4), 807–814.

Ballagas, R. A., Kratz, S. G., Borchers, J., Yu, E., Walz, S. P., Fuhr, C. O., Hovestadt, L., & Tann, M. (2007). Rexplorer: A mobile, pervasive spell-casting game for tourists, In *Chi'07 extended abstracts on human factors in computing systems*.

Bardis, P. D. (1979). Social interaction and social processes. *Social Science*, *54*(3), 147–167.

Barker, M., & Petley, J. (2013). Electronic child abuse?: Rethinking the media's effects on children, In *Ill effects*. Routledge.

Barnes, J. A. (1954). Class and committees in a norwegian island parish. *Human relations*, *7*(1), 39–58.

Bartle, R. (1996). Hearts, clubs, diamonds, spades: Players who suit muds. *Journal of MUD research*, *1*(1), 19.

Bartle, R. (2005). Virtual worlds: Why people play. *Massively multiplayer game development*, *2*(1), 3–18.

Beard, M. (2014). *Laughter in ancient rome: On joking, tickling, and cracking up* (Vol. 71). Univ of California Press.

Beauvais, C., & Jenson, J. (2002). *Social cohesion: Updating the state of the research* (Vol. 62). CPRN Ottawa.

Benford, S., Bederson, B. B., Åkesson, K.-P., Bayon, V., Druin, A., Hansson, P., Hourcade, J. P., Ingram, R., Neale, H., O'Malley, C., Et al. (2000). Designing storytelling technologies to encouraging collaboration between young children, In *Proceedings of the sigchi conference on human factors in computing systems*.

Berger, P. L., & Luckmann, T. (1991). *The social construction of reality: A treatise in the sociology of knowledge*. Penguin Uk.

Berkman, L. F., Kawachi, I., & Glymour, M. M. (2014). *Social epidemiology*. Oxford University Press.

Bilandzic, M., & Foth, M. (2012). A review of locative media, mobile and embodied spatial interaction. *International Journal of Human-Computer Studies*, *70*(1), 66–71.

Bjögvinsson, E., Ehn, P., & Hillgren, P.-A. (2012). Design things and design thinking: Contemporary participatory design challenges. *Design issues*, *28*(3), 101–116.

Bjork, S., & Holopainen, J. (2004). Patterns in game design (game development series), charles river media. *Inc., Rockland, MA*.

Björk, S., & Holopainen, J. (2006). Games and design patterns. *The game design reader*, 410–437.

Blanchard, C. M., Amiot, C. E., Perreault, S., Vallerand, R. J., & Provencher, P. (2009). Cohesiveness, coach's interpersonal style and psychological needs: Their effects on self-determination and athletes' subjective well-being. *Psychology of Sport and Exercise*, *10*(5), 545–551.

Blythe, M., & Monk, A. (2018). *Funology 2: From usability to enjoyment*. Springer.

Bollen, K. A., & Hoyle, R. H. (1990). Perceived cohesion: A conceptual and empirical examination. *Social forces*, *69*(2), 479–504.

Bostan, B., & Ogut, S. (2011). Presence in computer games: Design requirements. GAMEON.

Boyle, E., Connolly, T. M., & Hainey, T. (2011). The role of psychology in understanding the impact of computer games. *Entertainment Computing*, *2*(2), 69–74.

Braaten, L. J. (1991). Group cohesion: A new multidimensional model. *Group*, *15*(1), 39–55.

Brawley, L. R., Carron, A. V., & Widmeyer, W. N. (1987). Assessing the cohesion of teams: Validity of the group environment questionnaire. *Journal of Sport and Exercise Psychology*, *9*(3), 275–294.

Brazier, F., & Nevejan, C. (2014). Vision for participatory systems design, In *4th international engineering systems symposium (cesun 2014)*.

Broadwood, J., & Sugden, N. (2009). *Building cohesive communities: What frontline staff and community activists need to know*. Department for Communities; Local Government.

Brockmyer, J. H., Fox, C. M., Curtiss, K. A., McBroom, E., Burkhart, K. M., & Pidruzny, J. N. (2009). The development of the game engagement questionnaire: A measure of engagement in video game-playing. *Journal of Experimental Social Psychology*, *45*(4), 624–634.

Brooke, J. (1996). Sus: A quick and dirty usability scale. *Usability evaluation in industry*, 189.

Brown, E., & Cairns, P. (2004). A grounded investigation of game immersion, In *Chi'04 extended abstracts on human factors in computing systems*.

Brown, M. (1996). A framework for assessing participation, In *Critical systems thinking*. Springer.

Bruhn, J. (2009). The concept of social cohesion, In *The group effect*. Springer.

Bruhn, J. (2014). *Group effect*. Springer.

Budman, S. H., Demby, A., Feldstein, M., Redondo, J., Scherz, B., Bennett, M. J., Koppenaal, G., Daley, B. S., Hunter, M., & Ellis, J. (1987). Preliminary findings on a new instrument to measure cohesion in group psychotherapy. *International Journal of Group Psychotherapy*, *37*(1), 75–94.

Budman, S. H., Soldz, S., Demby, A., Feldstein, M., Springer, T., & Davis, M. S. (1989). Cohesion, alliance and outcome in group psychotherapy. *Psychiatry*, *52*(3), 339–350.

Burt, R. S. (1980). Models of network structure. *Annual review of sociology*, *6*(1), 79–141.

Cacioppo, J. T., & Patrick, W. (2008). *Loneliness: Human nature and the need for social connection*. WW Norton; Company.

Carron, A. V., Bray, S. R., & Eys, M. A. (2002). Team cohesion and team success in sport. *Journal of sports sciences*, *20*(2), 119–126.

Carron, A. V., Hausenblas, H. A., & Eys, M. A. (2005). *Group dynamics in sport*. Fitness Information Technology.

Carron, A. V., Widmeyer, W. N., & Brawley, L. R. (1985). The development of an instrument to assess cohesion in sport teams: The group environment questionnaire. *Journal of Sport and Exercise psychology*, *7*(3), 244–266.

Cartwright, D. (1951). Achieving change in people: Some applications of group dynamics theory. *Human Relations*, *4*(4), 381–392.

Checkland, P. (1999). Systems thinking. *Rethinking management information systems*, 45–56.

Cheok, A. D., Romão, T., Nijholt, A., & Yu, G. (2014). Entertaining the whole world, In *Entertaining the whole world*. Springer.

Cheong, P. H., Edwards, R., Goulbourne, H., & Solomos, J. (2007). Immigration, social cohesion and social capital: A critical review. *Critical social policy*, *27*(1), 24–49.

Chilufya, E. M. (2014). Hci: Design guidelines of mobile device games for the elderly.

Choi, D., & Kim, J. (2004). Why people continue to play online games: In search of critical design factors to increase customer loyalty to online contents. *CyberPsychology & behavior*, *7*(1), 11–24.

Chou, Y.-K. (2015). Octalysis: Complete gamification framework. *Acesso em*, *22*.

Cila, N., Giaccardi, E., Tynan–O'Mahony, F., Speed, C., & Caldwell, M. (2015). Thing–centered narratives: A study of object personas, In *Proceedings of the 3rd seminar international research network for design anthropology*.

Clark, A. M., & Clark, M. T. (2016). Pokémon go and research: Qualitative, mixed methods research, and the supercomplexity of interventions. SAGE Publications Sage CA: Los Angeles, CA.

CoE. (2008). Report of high-level task force on social cohesion: Towards an active, fair, and socially cohesive europe. Council of Europe Strasbourg.

Collins, C. R., Neal, J. W., & Neal, Z. P. (2014). Transforming individual civic engagement into community collective efficacy: The role of bonding social capital. *American journal of community psychology*, *54*(3-4), 328–336.

Consolvo, S., Everitt, K., Smith, I., & Landay, J. A. (2006). Design requirements for technologies that encourage physical activity, In *Proceedings of the sigchi conference on human factors in computing systems*.

Consolvo, S., Klasnja, P., McDonald, D. W., Avrahami, D., Froehlich, J., LeGrand, L., Libby, R., Mosher, K., & Landay, J. A. (2008). Flowers or a robot army? encouraging awareness & activity with personal, mobile displays, In *Proceedings of the 10th international conference on ubiquitous computing*.

Cooley, C. H. (1909). Social organization: A study of the larger mind. *Scribner's Sons*.

Couch, B. (2017). Playable cities: The city as a digital playground. SPRINGER HEIDELBERG TIERGARTENSTRASSE 17, D-69121 HEIDELBERG, GERMANY.

Coutts, L. M., & Schneider, F. W. (1975). Visual behavior in an unfocused interaction as a function of sex and distance. *Journal of experimental social psychology*, *11*(1), 64–77.

Cowan, B., & Kapralos, B. (2014). A survey of frameworks and game engines for serious game development, In *2014 ieee 14th international conference on advanced learning technologies*. IEEE.

Cowan, B., & Kapralos, B. (2017). An overview of serious game engines and frameworks, In *Recent advances in technologies for inclusive well-being*. Springer.

Crabtree, A., Benford, S., Capra, M., Flintham, M., Drozd, A., Tandavanitj, N., Adams, M., & Farr, J. R. (2007). The cooperative work of gaming: Orchestrating a mobile sms game. *Computer supported cooperative work (CSCW)*, *16*(1-2), 167–198.

Craighead, J., Burke, J., & Murphy, R. (2008). Using the unity game engine to develop sarge: A case study, In *Proceedings of the 2008 simulation workshop at the international conference on intelligent robots and systems (iros 2008)*.

Crossan, F. (2003). Research philosophy: Towards an understanding. *Nurse Researcher (through 2013)*, *11*(1), 46.

D'Andrea, A., Ferri, F., & Grifoni, P. (2010). An overview of methods for virtual social networks analysis, In *Computational social network analysis*. Springer.

Daneva, M. (2014). How practitioners approach gameplay requirements? an exploration into the context of massive multiplayer online role-playing games, In *2014 ieee 22nd international requirements engineering conference (re)*. IEEE.

Daneva, M. (2017). Striving for balance: A look at gameplay requirements of massively multiplayer online role-playing games. *Journal of systems and software*, *134*, 54–75.

De Lange, M. (2015). The playful city: Using play and games to foster citizen participation.

De Vries, S., Van Dillen, S. M., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social science & medicine*, *94*, 26–33.

de Cooperación y Desarrollo Económico, O. (2011). *Perspectives on global development 2012: Social cohesion in a shifting world*. OECD.

de Freitas, S., & Routledge, H. (2013). Designing leadership and soft skills in educational games: The e-leadership and soft skills educational games design model (eless). *British Journal of Educational Technology*, *44*(6), 951–968.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining gamification, In *Proceedings of the 15th international academic mindtrek conference: Envisioning future media environments*.

Deutsch, M. (1949). An experimental study of the effects of co-operation and competition upon group process. *Human relations*, *2*(3), 199–231.

DiSalvo, C., Nourbakhsh, I., Holstius, D., Akin, A., & Louw, M. (2008). The neighborhood networks project: A case study of critical engagement and creative expression through participatory design, In *Proceedings of the tenth anniversary conference on participatory design 2008*.

Distilled, U. (2003). A brief guide to the standard object modeling language», m. fowler. *K. Scott*.

Dix, A., Dix, A. J., Finlay, J., Abowd, G. D., & Beale, R. (2003). *Human-computer interaction*. Pearson Education.

Dobbernack, J. (2016). *The politics of social cohesion in germany, france and the united kingdom*. Springer.

Docomo, N. (2014). *Children's use of mobile phones: A special report* [[Online accessed on December 23, 2020]]. https://www.gsma.com/publicpolicy/wp-content/uploads/2012/03/GSMA_Childrens_use_of_mobile_phones_2014.pdf

Dormann, C., Whitson, J. R., & Neuvians, M. (2013). Once more with feeling: Game design patterns for learning in the affective domain. *Games and Culture*, *8*(4), 215–237.

Dorst, K. (2011). The core of 'design thinking'and its application. *Design studies*, *32*(6), 521–532.

Dragolov, G., Ignácz, Z. S., Lorenz, J., Delhey, J., Boehnke, K., & Unzicker, K. (2016). *Social cohesion in the western world: What holds societies together: Insights from the social cohesion radar*. Springer.

Druin, A. (2002). The role of children in the design of new technology. *Behaviour and information technology*, *21*(1), 1–25.

Duarte, S. (2015). *Revisiting the mda framework* [[Online accessed on December 23, 2020]]. https://www.gamasutra.com/blogs/LuizClaudioSilveiraDuarte/20150203/233487/Revisiting_the_MDA_framework.php

Duffy, M. K., Ganster, D. C., & Pagon, M. (2002). Social undermining in the workplace. *Academy of management Journal*, *45*(2), 331–351.

Duin, H., & Thoben, K.-D. (2011). Serious gaming for sustainable manufacturing: A requirements analysis, In *2011 17th international conference on concurrent enterprising*. IEEE.

Durkheim, E. (1897). *Le suicide: Étude de sociologie*. Alcan.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of engineering education*, *94*(1), 103–120.

Echeverria, S., Diez-Roux, A. V., Shea, S., Borrell, L. N., & Jackson, S. (2008). Associations of neighborhood problems and neighborhood social cohesion with mental health and health behaviors: The multi-ethnic study of atherosclerosis. *Health & place*, *14*(4), 853–865.

Egenfeldt-Nielsen, S., Smith, J. H., & Tosca, S. P. (2019). *Understanding video games: The essential introduction*. Routledge.

Ehn, P. (2008). Participation in design things, In *Proceedings participatory design conference 2008*. ACM.

Ehrmann, J., Lewis, C., & Lewis, P. (1968). Homo ludens revisited. *Yale French Studies*, (41), 31–57.

Erete, S. L. (2015). Engaging around neighborhood issues: How online communication affects offline behavior, In *Proceedings of the 18th acm conference on computer supported cooperative work & social computing*.

Eriksson, D. (2005). Socially adaptable games.

Ermi, L., & Mäyrä, F. (2005). Player-centred game design: Experiences in using scenario study to inform mobile game design. *Game Studies*, *5*(1), 1–10.

Fails, J. A., Guha, M. L., & Druin, A. (2013). Methods and techniques for involving children in the design of new technology for children. *Foundations and Trends in Human-Computer Interaction*, *6*(2), 85–166.

Festinger, L., Schachter, S., & Back, K. (1950). Social pressures in informal groups: A study of human factors in housing.

Fischer, J. E., Lindt, I., Stenros, J., Et al. (2007). *Evaluation of crossmedia gaming experiences in epidemic menace*. na.

Fitz-Walter, Z. J. (2015). *Achievement unlocked: Investigating the design of effective gamification experiences for mobile applications and devices* (Doctoral dissertation). Queensland University of Technology.

Flintham, M., Smith, K., Benford, S., Capra, M., Green, J., Greenhalgh, C., Wright, M., Adams, M., Tandavanitj, N., Farr, J. R., Et al. (2007). *Day of the figurines: A slow narrative-driven game for mobile phones using text messaging*. na.

Floden, R. E. (2009). Empirical research without certainty. *Educational theory*, *59*(4), 485–498.

Florian 'Floyd' Mueller, M. R. G., & Vetere, F. (2014). Designing for social and physical interaction in exertion games. *Playful User Interfaces: Interfaces that Invite Social and Physical Interaction*, 227.

Fonseca, X., Lukosch, S., & Brazier, F. (2018a). Fostering social interaction in playful cities, In *Interactivity, game creation, design, learning, and innovation*. Springer.

Fonseca, X., Lukosch, S., & Brazier, F. (2018b). Social cohesion revisited: A new definition and how to characterize it. *Innovation: The European Journal of Social Science Research*, *32*(2), 231–253.

Fonseca, X., Lukosch, S., & Brazier, F. (2020a). Modular software architecture for location-based games designed for social interaction in public space [Submitted to Entertainment Computing Journal, currently in review].

Fonseca, X., Lukosch, S., & Brazier, F. (2020b). What works? a framework for the design and analysis of activity types for location-based games for social interaction in public space [Submitted to Special issue on: 'Smart Cities at Play: Playful Approaches to Urban Space, and Problems of Participation', International journal of human-computer interaction, currently in review].

Fonseca, X., Lukosch, S., Lukosch, H., & Brazier, F. (2020). Requirements for location-based games for social interaction [Submitted to IEEE Transactions on Games, currently in review].

Fonseca, X., Lukosch, S., Lukosch, H., Tiemersma, S., & Brazier, F. (2017). Requirements and game ideas for social interaction in mobile outdoor games, In *Extended abstracts publication of the annual symposium on computer-human interaction in play*.

Fonseca, X., Slingerland, G., Lukosch, S., & Brazier, F. (2021). Designing for meaningful social interaction in digital serious games. *Entertainment Computing*, *36*(100385), 1–23. https://doi.org/10.1016/j.entcom.2020.100385

Foth, M., Forlano, L., Satchell, C., & Gibbs, M. (2011). *From social butterfly to engaged citizen: Urban informatics, social media, ubiquitous computing, and mobile technology to support citizen engagement*. MIT Press.

French, J. R., Raven, B., & Cartwright, D. (1959). The bases of social power. *Classics of organization theory*, *7*, 311–320.

Freud, S. (1923). *Massenpsychologie und ich-analyse*. Internationaler Psychoanalytischer Verlag.

Friedkin, N. E. (2004). Social cohesion. *Annu. Rev. Sociol.*, *30*, 409–425.

Friedmann, J. (2010). Place and place-making in cities: A global perspective. *Planning Theory & Practice*, *11*(2), 149–165.

Fuhriman, A., & Burlingame, G. M. (1994). *Handbook of group psychotherapy: An empirical and clinical synthesis* (Vol. 180). John Wiley & Sons.

Galinsky, A. D., Ku, G., & Wang, C. S. (2005). Perspective-taking and self-other overlap: Fostering social bonds and facilitating social coordination. *Group processes & intergroup relations*, *8*(2), 109–124.

Ganapathy, S. (2013). Design guidelines for mobile augmented reality: User experience, In *Human factors in augmented reality environments*. Springer.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & gaming*, *33*(4), 441–467.

Gaver, W. (2012). What should we expect from research through design?, In *Proceedings of the sigchi conference on human factors in computing systems*.

Gennari, R., Melonio, A., & Rizvi, M. (2019). Turn taking with turn-talk in group. *Multimedia Tools and Applications*, *78*(10), 13461–13487.

Gerling, K. M., Schild, J., & Masuch, M. (2010). Exergame design for elderly users: The case study of silverbalance, In *Proceedings of the 7th international conference on advances in computer entertainment technology*.

Gerling, K., Livingston, I., Nacke, L., & Mandryk, R. (2012). Full-body motion-based game interaction for older adults, In *Proceedings of the sigchi conference on human factors in computing systems*.

Gião, J., Sarraipa, J., Francisco-Xavier, F., Ferreira, F., Jardim-Goncalves, R., & Zdravkovic, M. (2016). Profiling based on music and physiological state, In *Enterprise interoperability vii*. Springer.

Gilligan, M. J., Pasquale, B. J., & Samii, C. (2014). Civil war and social cohesion: Lab-in-the-field evidence from nepal. *American Journal of Political Science*, *58*(3), 604–619.

Goffman, E. (1955). On face-work: An analysis of ritual elements in social interaction. *Psychiatry*, *18*(3), 213–231.

Goffman, E. (1961). *Encounters: Two studies in the sociology of interaction*. Ravenio Books.

Goffman, E. (2008). *Behavior in public places*. Simon; Schuster.

Goffman, E. Et al. (1978). *The presentation of self in everyday life*. Harmondsworth London.

Gooch, D., Barker, M., Hudson, L., Kelly, R., Kortuem, G., Linden, J. V. D., Petre, M., Brown, R., Klis-Davies, A., Forbes, H., Et al. (2018). Amplifying quiet voices: Challenges and opportunities for participatory design at an urban scale. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *25*(1), 1–34.

Gossain, S., & Anderson, B. (1990). An iterative-design model for reusable object-oriented software. *ACM SIGPLAN Notices*, *25*(10), 12–27.

Gough, I., & Olofsson, G. (1999). *Capitalism and social cohesion: Essays on exclusion and integration*. Springer.

Gould, J. D., & Lewis, C. (1985). Designing for usability: Key principles and what designers think. *Communications of the ACM*, *28*(3), 300–311.

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. *Nurse education today*, *24*(2), 105–112.

Granovetter, M. S. (1977). The strength of weak ties, In *Social networks*. Elsevier.

Grieve, F. G., Whelan, J. P., & Meyers, A. W. (2000). An experimental examination of the cohesion-performance relationship in an interactive team sport. *Journal of Applied Sport Psychology*, *12*(2), 219–235.

Grimaldo, A. I., Morán, A. L., Gamez, E. C., Cairns, P., Palacio, R. R., & Meza-Kubo, V. (2014). Promoting elderly-children interaction in digital games: A preliminary set of design guidelines, In *Cyted-ritos international workshop on groupware*. Springer.

Groenewegen, P. P., Van den Berg, A. E., De Vries, S., & Verheij, R. A. (2006). Vitamin g: Effects of green space on health, well-being, and social safety. *BMC public health*, *6*(1), 1–9.

Guha, M. L., Druin, A., Chipman, G., Fails, J. A., Simms, S., & Farber, A. (2004). Mixing ideas: A new technique for working with young children as design partners, In *Proceedings of the 2004 conference on interaction design and children: Building a community*.

Gunter, G., Kenny, R. F., & Vick, E. H. (2006). A case for a formal design paradigm for serious games. *The Journal of the International Digital Media and Arts Association*, *3*(1), 93–105.

Haag, D. (2017). *Wijkprogramma's escamp 2016-2019* [[Online accessed on December 23, 2020]]. https://www.denhaag.nl/nl/in-de-stad/stadsdelen/escamp/wijkprogrammas-escamp-2016-2019.htm

Harpine, E. C. (2011). Group cohesion: The therapeutic factor in groups, In *Group-centered prevention programs for at-risk students*. Springer.

Harteveld, C. (2011). *Triadic game design: Balancing reality, meaning and play*. Springer Science & Business Media.

Hassan, L., & Thibault, M. (2020). Critical playable cities, In *Making smart cities more playable*. Springer.

Hauge, J. B., Söbke, H., Stefan, I. A., & Stefan, A. (2019). Designing serious mobile location-based games, In *Joint international conference on entertainment computing and serious games*. Springer.

Helbing, D. (2016). *Engineering social technologies for a responsible digital future: A research program at the faculty of technology, policy and management (tpm)* [[Online accessed on December 23, 2020]]. https://www.tudelft.nl/en/tpm/research/projects/engineering-social-technologies-for-a-responsible-digital-future/

Helbing, D., Frey, B. S., Gigerenzer, G., Hafen, E., Hagner, M., Hofstetter, Y., Van Den Hoven, J., Zicari, R. V., & Zwitter, A. (2019). Will democracy survive big data and artificial intelligence?, In *Towards digital enlightenment*. Springer.

Hickman, M. J., Mai, N., & Crowley, H. (2012). *Migration and social cohesion in the uk*. Springer.

Hinske, S., Langheinrich, M., & Lampe, M. (2008). Towards guidelines for designing augmented toy environments, In *Proceedings of the 7th acm conference on designing interactive systems*.

Hirsch, T. (2011). More than friends: Social and mobile media for activist organizations. *From Social Butterfly to Engaged Citizen*, 135–150.

Hirschheim, R. (1985). Information systems epistemology: An historical perspective. *Research methods in information systems*, *9*, 13–35.

Hochschild, A. R. (1979). Emotion work, feeling rules, and social structure. *American journal of sociology*, *85*(3), 551–575.

Hodson, H. (2012). Google's ingress game is a gold mine for augmented reality. Elsevier.

Hogg, M. A., & Turner, J. C. (1985). Interpersonal attraction, social identification and psychological group formation. *European journal of social psychology*, *15*(1), 51–66.

Høigaard, R., Säfvenbom, R., & Tønnessen, F. E. (2006). The relationship between group cohesion, group norms, and perceived social loafing in soccer teams. *Small group research*, *37*(3), 217–232.

Homans, G. C. (1958). Social behavior as exchange. *American journal of sociology*, *63*(6), 597–606.

Hornbek, K. S., & Jensen, J. (n.d.). Bjørnetjeneste: Using the city as a backdrop for location–based interactive narratives.

Hossenlopp, R., PMP, R. H., Hass, K. B., & PMP, K. B. H. (2007). *Unearthing business requirements: Elicitation tools and techniques*. Berrett-Koehler Publishers.

Hourcade, J. P. (2008). *Interaction design and children*. Now Publishers Inc.
Huizinga, J. (1955). Homo ludens: A study of the play element in culture. *Beacon Press (in English)*, *55*.
Huizinga, J., & Seresia, C. (1952). Homo ludens: Essai sur la fonction sociale du jeu.
Hunicke, R., LeBlanc, M., & Zubek, R. (2004). Mda: A formal approach to game design and game research, In *Proceedings of the aaai workshop on challenges in game ai*.
Ibrahim, S., & Alkire, S. (2007). Agency and empowerment: A proposal for internationally comparable indicators. *Oxford development studies*, *35*(4), 379–403.
Inal, Y., & Cagiltay, K. (2007). Flow experiences of children in an interactive social game environment. *British Journal of Educational Technology*, *38*(3), 455–464.
Innocent, T. (2020). Citizens of play: Revisiting the relationship between playable and smart cities, In *Making smart cities more playable*. Springer.
Isbister, K., & Mueller, F. F. (2015). Guidelines for the design of movement-based games and their relevance to hci. *Human Computer Interaction*, *30*(3-4), 366–399.
Ishii, H., Kobayashi, M., & Arita, K. (1994). Iterative design of seamless collaboration media. *Communications of the ACM*, *37*(8), 83–97.
Iversen, O. S., Smith, R. C., & Dindler, C. (2017). Child as protagonist: Expanding the role of children in participatory design, In *Proceedings of the 2017 conference on interaction design and children*.
Jacob, J. T. P. N., & Coelho, A. F. (2011). Issues in the development of location-based games. *International Journal of Computer Games Technology*, *2011*.
Janis, I. L. (1972). Victims of groupthink: A psychological study of foreign-policy decisions and fiascoes.
Järvinen, A. S. (2009). *Games without frontiers: Methods for game studies and design*. VDM Verlag Dr. Müller.
Jeannotte, M. S. (2003). Singing alone? the contribution of cultural capital to social cohesion and sustainable communities. *The International Journal of Cultural Policy*, *9*(1), 35–49.
Jenson, J. (2010). *Defining and measuring social cohesion*. Commonwealth Secretariat.
Jiménez, S., & Escribano, F. (2017). Gamification model canvas. *Visited on January*.
Jones, C. E., Theodosis, S., & Lykourentzou, I. (2019). The enthusiast, the interested, the sceptic, and the cynic: Understanding user experience and perceived value in location-based cultural heritage games through qualitative and sentiment analysis. *Journal on Computing and Cultural Heritage (JOCCH)*, *12*(1), 1–26.
Kasapakis, V., & Gavalas, D. (2015). Pervasive gaming: Status, trends and design principles. *Journal of Network and Computer Applications*, *55*, 213–236.
Kasurinen, J., Maglyas, A., & Smolander, K. (2014). Is requirements engineering useless in game development?, In *International working conference on requirements engineering: Foundation for software quality*. Springer.
Kendall, L., & Dearden, A. (2018). Disentangling participatory ict design in socioeconomic development, In *Proceedings of the 15th participatory design conference: Full papers-volume 1*.
Kim, D., Subramanian, S. V., & Kawachi, I. (2008). Social capital and physical health, In *Social capital and health*. Springer.

Kim, Y.-C., & Ball-Rokeach, S. J. (2006). Civic engagement from a communication infrastructure perspective. *Communication Theory*, *16*(2), 173–197.

Kinnula, M., & Iivari, N. (2019). Empowered to make a change: Guidelines for empowering the young generation in and through digital technology design, In *Proceedings of the fablearn europe 2019 conference*.

Kniestedt, I., Lukosch, S., & Brazier, F. (2018). User-centered design of an online mobile game suite to affect well-being of older adults, In *International conference on entertainment computing*. Springer.

Korhonen, H., & Koivisto, E. M. (2007). Playability heuristics for mobile multi-player games, In *Proceedings of the 2nd international conference on digital interactive media in entertainment and arts*.

Korhonen, H., Saarenpää, H., & Paavilainen, J. (2008). Pervasive mobile games - a new mindset for players and developers, In *International conference on fun and games*. Springer.

Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., & Wensveen, S. (2011). *Design research through practice: From the lab, field, and showroom*. Elsevier.

Krackhardt, D. (1990). Assessing the political landscape: Structure, cognition, and power in organizations. *Administrative science quarterly*, 342–369.

Kroeze, C., & Olivier, M. S. (2012). Gamifying authentication, In *2012 information security for south africa*. IEEE.

Kuijer, L., Jong, A. d., & Eijk, D. v. (2013). Practices as a unit of design: An exploration of theoretical guidelines in a study on bathing. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *20*(4), 1–22.

Kumar, J. (2013). Gamification at work: Designing engaging business software, In *International conference of design, user experience, and usability*. Springer.

Kusnandar, K., Brazier, F., & van Kooten, O. (2019). Empowering change for sustainable agriculture: The need for participation. *International Journal of Agricultural Sustainability*, *17*(4), 271–286.

Laamarti, F., Eid, M., & El Saddik, A. (2014). An overview of serious games. *International Journal of Computer Games Technology*, *2014*.

Lancel, K., Maat, H., & Brazier, F. (2019). Hosting social touch in public space of merging realities, In *Interactivity, game creation, design, learning, and innovation*. Springer.

Lancel, K., Maat, H., & Brazier, F. (2020a). Designing disruption for social touch, in public spaces of merging realities: A multi-sensory model. *International Journal of Arts and Technology*, *12*(1), 18–38.

Lancel, K., Maat, H., & Brazier, F. (2020b). Saving face: Shared experience and dialogue on social touch, in playful smart public space, In *Making smart cities more playable*. Springer.

Larsen, C. A. (2013). *The rise and fall of social cohesion: The construction and de-construction of social trust in the us, uk, sweden and denmark*. Oxford University Press.

Laumann, E. O. (1973). *Bonds of pluralism: The form and substance of urban social networks*. New York: J. Wiley.

Le Bon, G. (1897). *The crowd: A study of the popular mind*. T. Fisher Unwin.

Lewin, K. (1946). Behavior and development as a function of the total situation.

Lin, J. J., Mamykina, L., Lindtner, S., Delajoux, G., & Strub, H. B. (2006). Fish'n'steps: Encouraging physical activity with an interactive computer game, In *International conference on ubiquitous computing*. Springer.

Ling, R., & Wong, A. (2011). Mobile interactions as social machines: Poor urban youth at play in bangladesh, In *From social butterfly to engaged citizen*. MIT Press.

Lippitt, R. (1943). The psychodrama in leadership training. *Sociometry*, *6*(3), 286–292.

Lippitt, R., & White, R. K. (1943). The social climate of children's groups.

Liu, Y., Alexandrova, T., & Nakajima, T. (2011). Gamifying intelligent environments, In *Proceedings of the 2011 international acm workshop on ubiquitous meta user interfaces*.

Lockwood, D. (1999). Civic integration and social cohesion, In *Capitalism and social cohesion*. Springer.

Lott, A. J., & Lott, B. E. (1961). Group cohesiveness, communication level, and conformity. *The Journal of Abnormal and Social Psychology*, *62*(2), 408.

Lott, A. J., & Lott, B. E. (1966). Group cohesiveness and individual learning. *Journal of Educational Psychology*, *57*(2), 61.

Lott, A. J., & Lott, B. E. (1969). Liked and disliked persons as reinforcing stimuli. *Journal of personality and social psychology*, *11*(2), 129.

Lownsbrough, H., & Beunderman, J. (2007). *Equally spaced?: Public space and interaction between diverse communities: A report for the commission for racial equality*. Demos London.

LumenLearning. (2018). *Understanding social interaction* [[Online accessed on December 23, 2020]]. https://courses.lumenlearning.com/boundless-sociology/chapter/understanding-social-interaction/

MacKenzie, K. R. (1981). Measurement of group climate. *International Journal of Group Psychotherapy*, *31*(3), 287–295.

MacKenzie, K. R., Dies, R. R., Coché, E., Rutan, J. S., & Stone, W. N. (1987). An analysis of agpa institute groups. *International Journal of Group Psychotherapy*, *37*(1), 55–74.

Mair, C., Roux, A. V. D., & Morenoff, J. D. (2010). Neighborhood stressors and social support as predictors of depressive symptoms in the chicago community adult health study. *Health & place*, *16*(5), 811–819.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive science*, *5*(4), 333–369.

Mandryk, R. L., Gerling, K. M., & Stanley, K. G. (2014). Designing games to discourage sedentary behaviour, In *Playful user interfaces*. Springer.

Mascio, T. D., Gennari, R., Melonio, A., & Vittorini, P. (2013). Designing games for deaf children: First guidelines. *International Journal of Technology Enhanced Learning*, *5*(3-4), 223–239.

Maxwell, J. (1996). *Social dimensions of economic growth*. Department of Economics, University of Alberta.

McDougall, W. (1920). *The group mind: A sketch of the principles of collective psychology, with some attempt to apply them to the interpretation of national life and character*. GP Putnam's sons.

McMillan, D. W., & Chavis, D. M. (1986). Sense of community: A definition and theory. *Journal of community psychology*, *14*(1), 6–23.

McShaffry, M. (2014). *Game coding complete*. Nelson Education.

Mellecker, R., Lyons, E. J., & Baranowski, T. (2013). Disentangling fun and enjoyment in exergames using an expanded design, play, experience framework: A narrative review. *GAMES FOR HEALTH: Research, Development, and Clinical Applications*, *2*(3), 142–149.

Menestrina, Z. (2017). *The g3p framework: Guiding the design process of games for purpose* (Doctoral dissertation). University of Trento.

Meyer, B. B. (2000). The ropes and challenge course: A quasi-experimental examination. *Perceptual and Motor Skills*, *90*(3_suppl), 1249–1257.

Miesenberger, K., Ossmann, R., Archambault, D., Searle, G., & Holzinger, A. (2008). More than just a game: Accessibility in computer games, In *Symposium of the austrian hci and usability engineering group*. Springer.

Milgram, S. (1965). Some conditions of obedience and disobedience to authority. *Human relations*, *18*(1), 57–76.

Mizukami, T. (2016). *Creating social cohesion in an interdependent world: Experiences of australia and japan*. Springer.

Mondada, L. (2009). Emergent focused interactions in public places: A systematic analysis of the multimodal achievement of a common interactional space. *Journal of pragmatics*, *41*(10), 1977–1997.

Moody, J., & White, D. R. (2003). Structural cohesion and embeddedness: A hierarchical concept of social groups. *American sociological review*, 103–127.

Mora, A., Riera, D., Gonzalez, C., & Arnedo-Moreno, J. (2015). A literature review of gamification design frameworks, In *2015 7th international conference on games and virtual worlds for serious applications (vs-games)*. IEEE.

Moreno, J. L. (1934). Who shall survive?: A new approach to the problem of human interrelations.

Morschheuser, B., Hamari, J., Werder, K., & Abe, J. (2017). How to gamify? a method for designing gamification, In *Proceedings of the 50th hawaii international conference on system sciences 2017*. University of Hawai'i at Manoa.

Mueller, F. '., Gibbs, M. R., Vetere, F., & Edge, D. (2017). Designing for bodily interplay in social exertion games. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *24*(3), 1–41.

Mueller, F., Vetere, F., Gibbs, M. R., Agamanolis, S., & Sheridan, J. (2010). Jogging over a distance: The influence of design in parallel exertion games, In *Proceedings of the 5th acm siggraph symposium on video games*.

Mullen, J. D. (2013). Location-based games and augmented reality systems [US Patent 8,585,476]. Google Patents.

Naliuka, K., Carrigy, T., Paterson, N., & Haahr, M. (2010). A narrative architecture for story-driven location-based mobile games, In *International conference on web-based learning*. Springer.

Nesset, V., & Large, A. (2004). Children in the information technology design process: A review of theories and their applications. *Library & Information Science Research*, *26*(2), 140–161.

Nicotera, N. (2008). Building skills for civic engagement: Children as agents of neighborhood change. *Journal of Community Practice*, *16*(2), 221–242.

Nielsen, J. (1993). Iterative user-interface design. *Computer*, *26*(11), 32–41.

Nieuwenhuys, C. (1974). New babylon. *Constant: New Babylon*, *154*.

Nijholt, A. (2017a). Playable cities: A short survey (keynote paper), In *2017 6th international conference on informatics, electronics and vision & 2017 7th international symposium in computational medical and health technology (iciev-iscmht)*. IEEE.

Nijholt, A. (2017b). Towards playful and playable cities, In *Playable cities*. Springer.

Nilsen, T. (2006). Guidelines for the design of augmented reality strategy games.

Nolêto, C., Lima, M., Maia, L. F., Viana, W., & Trinta, F. (2015). An authoring tool for location-based mobile games with augmented reality features, In *2015 14th brazilian symposium on computer games and digital entertainment (sbgames)*. IEEE.

Novy, A., Swiatek, D. C., & Moulaert, F. (2012). Social cohesion: A conceptual and political elucidation. *Urban studies*, *49*(9), 1873–1889.

of Communities, D., & Government, L. (2009). Guidance on meaningful interaction: How encouraging positive relationships between people can help build community cohesion.

of Pediatrics, A. A. Et al. (2009). Policy statement–media violence. *Pediatrics*, *124*(5), 1495–1503.

Ohmer, M. L. (2016). Strategies for preventing youth violence: Facilitating collective efficacy among youth and adults. *Journal of the Society for Social Work and Research*, *7*(4), 681–705.

Oppermann, L., & Slussareff, M. (2016). Pervasive games, In *Entertainment computing and serious games*. Springer.

O'Shea, Z., & Freeman, J. (2019). Game design frameworks: Where do we start?, In *Proceedings of the 14th international conference on the foundations of digital games*.

Paavilainen, J., Korhonen, H., Saarenpää, H., & Holopainen, J. (2009). Player perception of context information utilization in pervasive mobile games., In *Digra conference*.

Paay, J., & Kjeldskov, J. (2005). Understanding situated social interactions in public places, In *Ifip conference on human-computer interaction*. Springer.

Paelke, V., Oppermann, L., & Reimann, C. (2008). Mobile location-based gaming, In *Map-based mobile services*. Springer.

Pahl, R. E. (1991). The search for social cohesion: From durkheim to the european commission. *European Journal of Sociology/Archives Européennes de Sociologie*, *32*(2), 345–360.

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.

Parsons, D., Ryu, H., & Cranshaw, M. (2006). A study of design requirements for mobile learning environments, In *Sixth ieee international conference on advanced learning technologies (icalt'06)*. IEEE.

Parsons, T. (1991). *The social system*. Psychology Press.

Paulos, E., Kim, S., & Kuznetsov, S. (2011). The rise of the expert amateur: Citizen science and microvolunteerism. *From Social Butterfly to Engaged Citizen: Urban Infor-*

matics, Social Media, Ubiquitous Computing, and Mobile Technology to Support Citizen Engagement, 167.

Peitz, J., Saarenpää, H., & Björk, S. (2007). Insectopia: Exploring pervasive games through technology already pervasively available, In *Proceedings of the international conference on advances in computer entertainment technology*.

Persell, C. H. Et al. (1984). Understanding society: An introduction to sociology.

Peters, K., Elands, B., & Buijs, A. (2010). Social interactions in urban parks: Stimulating social cohesion? *Urban forestry & Urban greening*, *9*(2), 93–100.

Peterson, N. A., & Hughey, J. (2004). Social cohesion and intrapersonal empowerment: Gender as moderator. *Health education research*, *19*(5), 533–542.

Phillips, D. (2006). *Quality of life: Concept, policy and practice*. Routledge.

Pink, S. (2008). An urban tour: The sensory sociality of ethnographic place-making. *Ethnography*, *9*(2), 175–196.

Piper, W. E., Marrache, M., Lacroix, R., Richardsen, A. M., & Jones, B. D. (1983). Cohesion as a basic bond in groups. *Human Relations*, *36*(2), 93–108.

Polansky. (2015). *On genre and the ludic device* [[Online accessed on December 23, 2020]]. http://sufficientlyhuman.com/archives/1008

Polansky, N., Lippitt, R., & Redl, F. (1950). An investigation of behavioral contagion in groups. *Human Relations*, *3*(4), 319–348.

Preece, J., Sharp, H., & Rogers, Y. (2015). *Interaction design: Beyond human-computer interaction*. John Wiley & Sons.

Prensky, M. (2001). Fun, play and games: What makes games engaging. *Digital game-based learning*, *5*(1), 5–31.

Putnam, H. (1975). The meaning of 'meaning'. *Philosophical papers*, *2*.

Pyae, A., Luimula, M., & Smed, J. (2017). Investigating players' engagement, immersion, and experiences in playing pokémon go, In *Proceedings of the 2017 acm sigchi conference on creativity and cognition*.

Qin, H., Rau, P.-L. P., & Salvendy, G. (2010). Effects of different scenarios of game difficulty on player immersion. *Interacting with Computers*, *22*(3), 230–239.

Ralph, P., & Monu, K. (2014). Mtda+ n–a working theory of game design. *First Person Scholar*.

Rapoport, A., & Horvath, W. J. (1961). A study of a large sociogram. *Behavioral science*, *6*(4), 279–291.

Rashid, O., Mullins, I., Coulton, P., & Edwards, R. (2006). Extending cyberspace: Location based games using cellular phones. *Computers in Entertainment (CIE)*, *4*(1), 4–es.

Reer, F., & Krämer, N. C. (2019). Are online role-playing games more social than multiplayer first-person shooters? investigating how online gamers' motivations and playing habits are related to social capital acquisition and social support. *Entertainment Computing*, *29*, 1–9.

Reitz, J. G., Breton, R., Dion, K. K., & Dion, K. L. (2009). *Multiculturalism and social cohesion: Potentials and challenges of diversity*. Springer Science & Business Media.

Reuter, C., Wendel, V., Göbel, S., & Steinmetz, R. (2014). Game design patterns for collaborative player interactions., In *Digra*.

Robertson, T., & Simonsen, J. (2012). Challenges and opportunities in contemporary participatory design. *Design Issues*, *28*(3), 3–9.

Rodriguez, H. (2006). The playful and the serious: An approximation to huizinga's homo ludens. *Game Studies*, *6*(1), 1604–7982.

Rowe, P. G. (1987). *Design thinking*. MIT press.

Ryan, A. B. (2006). Post-positivist approaches to research. *Researching and Writing your Thesis: a guide for postgraduate students*, 12–26.

Saldaña, J. (2015). *The coding manual for qualitative researchers*. Sage.

Salen, K., Tekinbas, K. S., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. MIT press.

Schachter, S., Ellertson, N., McBride, D., & Gregory, D. (1951). An experimental study of cohesiveness and productivity. *Human Relations*, *4*(3), 229–238.

Schell, J. (2008). *The art of game design: A book of lenses*. CRC press.

Schouten, B., Ferri, G., de Lange, M., & Millenaar, K. (2017). Games as strong concepts for city-making, In *Playable cities*. Springer.

Schuler, D., & Namioka, A. (1993). *Participatory design: Principles and practices*. CRC Press.

Sherif, M., & Sherif, C. W. (1969). Ingroup and intergroup relations: Experimental analysis. *Social psychology*, 221–266.

Siakavaras, I., Papastergiou, M., & Comoutos, N. (2018). Mobile games in computer science education: Current state and proposal of a mobile game design that incorporates physical activity, In *Research on e-learning and ict in education*. Springer.

Silbergeld, S., Koenig, G. R., Manderscheid, R. W., Meeker, B. F., & Hornung, C. A. (1975). Assessment of environment-therapy systems: The group atmosphere scale. *Journal of Consulting and Clinical Psychology*, *43*(4), 460.

Siriaraya, P., Visch, V., Vermeeren, A., & Bas, M. (2018). A cookbook method for persuasive game design. *International Journal of Serious Games*, *5*(1).

Sisarica, A. (2015). *Creativity support in games for motivated learning.* (Doctoral dissertation). City University London.

Slingerland, G., Fonseca, X., Lukosch, S., & Brazier, F. (2020). Location-based challenges for playful neighbourhood exploration. *Behaviour and Information Technology*. https://doi.org/10.1080/0144929X.2020.1829707

Slingerland, G., Lukosch, S., & Brazier, F. (2020). Engaging children to co-create outdoor play activities for place-making, In *Proceedings of the 16th participatory design conference 2020-participation (s) otherwise-volume 1*.

Slingerland, G., Lukosch, S., Comes, T., & Brazier, F. (2018). Exploring requirements for joint information sharing in neighbourhoods: Local playgrounds in the hague, In *Interactivity, game creation, design, learning, and innovation*. Springer.

Slingerland, G., Lukosch, S., Comes, T., & Brazier, F. (2020). Exploring design guidelines for fostering citizen engagement through information sharing: Local playgrounds in the hague. *EAI Endorsed Transactions on Serious Games*.

Slingerland, G., Mulder, I., & Jaskiewicz, T. (2019). Join the park! exploring opportunities to lower the participation divide in park communities, In *Proceedings of the 9th international conference on communities & technologies-transforming communities*.

Smeddinck, J. D., Herrlich, M., Wang, X., Zhang, G., & Malaka, R. (2019). Work hard, play hard: How linking rewards in games to prior exercise performance improves motivation and exercise intensity. *Entertainment Computing*, *29*, 20–30.

Söbke, H., & Streicher, A. (2016). Serious games architectures and engines, In *Entertainment computing and serious games*. Springer.

Sotamaa, O. (2002). All the world's a botfighter stage: Notes on location-based multi-user gaming., In *Cgdc conf.* Citeseer.

Stein, A., Yotam, Y., Puzis, R., Shani, G., & Taieb-Maimon, M. (2018). Eeg-triggered dynamic difficulty adjustment for multiplayer games. *Entertainment computing*, *25*, 14–25.

Stevens, Q. (2007). *The ludic city: Exploring the potential of public spaces*. Routledge.

Stokes, B., Dols, S., & Hill, A. (2018). Cities remix a playful platform: Prominent experiments to embed pokémon go, from open streets to neighborhood libraries. *Retrieved from American University website: https://playfulcity. net/go/pokemon-report*.

Stokes, J. P. (1983). Components of group cohesion: Intermember attraction, instrumental value, and risk taking. *Small Group Behavior*, *14*(2), 163–173.

Straker, L., Abbott, R., Collins, R., & Campbell, A. (2014). Evidence-based guidelines for wise use of electronic games by children. *Ergonomics*, *57*(4), 471–489.

Sweeney, L. B., & Meadows, D. (2010). *The systems thinking playbook: Exercises to stretch and build learning and systems thinking capabilities*. Chelsea Green Publishing.

Tanghe, K. B. (2016). Homo ludens (1938) and the crisis in the humanities. *Cogent Arts & Humanities*, *3*(1), 1245087.

Tondello, G. F., Arrambide, K., Ribeiro, G., Cen, A. J.-l., & Nacke, L. E. (2019). I don't fit into a single type: A trait model and scale of game playing preferences, In *Ifip conference on human-computer interaction*. Springer.

Tondello, G. F., & Nacke, L. E. (2019). Player characteristics and video game preferences, In *Proceedings of the annual symposium on computer-human interaction in play*.

Tsekleves, E., Cosmas, J., & Aggoun, A. (2016). Benefits, barriers and guideline recommendations for the implementation of serious games in education for stakeholders and policymakers. *British Journal of Educational Technology*, *47*(1), 164–183.

Valente, L., Feijó, B., & do Prado Leite, J. C. S. (2017). Mapping quality requirements for pervasive mobile games. *Requirements Engineering*, *22*(1), 137–165.

Van Vianen, A. E., & De Dreu, C. K. (2001). Personality in teams: Its relationship to social cohesion, task cohesion, and team performance. *European Journal of Work and Organizational Psychology*, *10*(2), 97–120.

van Delden, R. W. (2017). (steering) interactive play behavior.

Verkuyten, M. (2010). Assimilation ideology and situational well-being among ethnic minority members. *Journal of Experimental Social Psychology*, *46*(2), 269–275.

Vertovec, S. (1999). Migration and social cohesion.

Voulis, N. (2019). Harnessing heterogeneity: Understanding urban demand to support the energy transition.

Wagner-Greene, V. R., Wotring, A. J., Castor, T., Kruger, J., Mortemore, S., & Dake, J. A. (2017). Pokémon go: Healthy or harmful? *American journal of public health*, *107*(1), 35.

Walk, W., Görlich, D., & Barrett, M. (2017). Design, dynamics, experience (dde): An advancement of the mda framework for game design, In *Game dynamics*. Springer.

Weber, R. (2004). Editor's comments: The rhetoric of positivism versus interpretivism: A personal view. *MIS quarterly*, iii–xii.

Wellman, B., & Wortley, S. (1990). Different strokes from different folks: Community ties and social support. *American journal of Sociology*, *96*(3), 558–588.

Werbach, K., & Hunter, D. (2012). *For the win: How game thinking can revolutionize your business*. Wharton Digital Press.

Wetzel, R., McCall, R., Braun, A.-K., & Broll, W. (2008). Guidelines for designing augmented reality games, In *Proceedings of the 2008 conference on future play: Research, play, share*.

White, H. C., Boorman, S. A., & Breiger, R. L. (1976). Social structure from multiple networks. i. blockmodels of roles and positions. *American journal of sociology*, *81*(4), 730–780.

Whitton, S. M., & Fletcher, R. B. (2014). The group environment questionnaire: A multilevel confirmatory factor analysis. *Small Group Research*, *45*(1), 68–88.

Yang, C.-c., & Liu, D. (2017). Motives matter: Motives for playing pokémon go and implications for well-being. *Cyberpsychology, Behavior, and Social Networking*, *20*(1), 52–57.

Yim, J. W. (2008). *Computer-aided exercise* (Doctoral dissertation).

Yim, J., & Graham, T. N. (2007). Using games to increase exercise motivation, In *Proceedings of the 2007 conference on future play*.

Zagal, J. P., Nussbaum, M., & Rosas, R. (2000). A model to support the design of multiplayer games. *Presence: Teleoperators & Virtual Environments*, *9*(5), 448–462.

Zendle, D., Kudenko, D., & Cairns, P. (2018). Behavioural realism and the activation of aggressive concepts in violent video games. *Entertainment computing*, *24*, 21–29.

Zichermann, G., & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps*. O'Reilly Media, Inc.

Zimmerman, J., & Forlizzi, J. (2014). Research through design in hci, In *Ways of knowing in hci*. Springer.

Zimmerman, J., Forlizzi, J., & Evenson, S. (2007). Research through design as a method for interaction design research in hci, In *Proceedings of the sigchi conference on human factors in computing systems*.

List of Figures

List of Tables

List of Publications

9. **X. Fonseca**, G. Slingerland, S. Lukosch, and F. Brazier, *Designing for Meaningful Social Interaction in Digital Serious Games*, Entertainment Computing Journal, doi: https://doi.org/10.1016/j.entcom.2020.100385, 2020.

8. **X. Fonseca**, S. Lukosch, and F. Brazier, *Secrets of the South: A Location-based Game for the Development of 21st Century Social Skills and Promotion of Social Interaction*, Proceedings of DELbA 2020 Workshop on Designing and Facilitating Educational Location-based Applications co-located with the Fifteenth European Conference on Technology Enhanced Learning (EC-TEL 2020), Heidelberg, Germany, 2020.

7. **X. Fonseca**, S. Lukosch, and F. Brazier, *What Works? A Framework for the Design and Analysis of Activity Types for Location-based Games for Social Interaction in Public Space*, 2020 (Submitted to Special issue on: 'Smart Cities at Play: Playful Approaches to Urban Space, and Problems of Participation', International journal of human-computer interaction, currently in review).

6. **X. Fonseca**, S. Lukosch, H. Lukosch, and F. Brazier, *Requirements for Location-based Games for Social Interaction*, 2020 (Submitted to IEEE Transactions on Games, currently in review).

5. **X. Fonseca**, S. Lukosch, and F. Brazier, *Modular Software Architecture for Location-based Games Designed for Social Interaction in Public Space*, 2020 (Submitted to Entertainment Computing Journal, currently in review).

4. G. Slingerland, **X. Fonseca**, S. Lukosch, and F. Brazier, *Location-based Challenges for Playful Neighbourhood Exploration*, Behaviour and Information Technology, doi: https://doi.org/10.1080/0144929X.2020.1829707, 2020.

3. G. Slingerland, **X. Fonseca**, S. Lukosch, and F. Brazier, *Designing Outdoor Playgrounds forIncreased Civic Engagement*, CHI '19, May 4-9, Glasgow, UK, 2019.

2. **X. Fonseca**, S. Lukosch, and F. Brazier, *Social Cohesion Revisited: A New Definition and How to Characterize it*, Innovation: The European Journal of Social Science Research, vol.32, no. 2, pp. 231-253, 2018.

1. **X. Fonseca**, S. Lukosch, H. Lukosch, S. Tiemersma, and F. Brazier, *Requirements and game ideas for social interaction in mobile outdoor games*, Extended Abstracts Publication of the Annual Symposium on Computer-Human Interaction in Play, p. 331 - 337, 2017.

ACRONYMS

Acronym	Description
2D/3D	Two-dimensional / Three-dimensional
(A-)GPS	(Assisted) Global Positioning System
API	Application Programming Interface
AR	Augmented Reality
CMS	Content Management System
CoE	Council of Europe
GEQ	Game Engagement Questionnaire
ID	Identification
IT	Information Technology
LBG(s)	Location-based game(s)
MCD	Mobile Computing Device
MDA	Mechanics-Dynamics-Aesthetics Framework
NL	The Netherlands
OECD	Organisation for Economic Co-operation and Development
POI(s)	Point(s) of Interest
QR	Quick Response Code
RtD	Research through Design
RVC	Rotterdams Vakcollege
SCF	Social Cohesion Framework
SMS	Short Message Service
SNA	Social Network Analysis
SotS	Secrets of the South
STC	Scheepvaart en Transport College
TGD	Triadic Game Design
UML	Unified Modelling Language
URL	Uniform Resource Locator

Translations

Original	Translation	Chapter
Tu podes descobrir mais sobre uma pessoa numa hora de brincadeira do que num ano de conversa.	You can find out more about a person in one hour of play than in a year of conversation.	Preface
Um testemunho de força, resiliência, pura loucura, e persistência. Uma jornada de batalhas e vitórias até aos ombros do gigante que é o conhecimento. Obrigado a vós, todos vós que me quereis bem e não me vacilais no vosso apoio e presença.	*A testimony of strength, resilience, pure madness, and persistence. A journey of battles and victories all the way up to the shoulders of the giant that is knowledge.* Thank you, to all of you who wish me well and do not waver in your support and presence.	Preface
Obrigado por tudo, miúda.	Thank you for everything, sweetheart.	Ack.
As pessoas são solitárias porque constroem muros ao invés de pontes.	People are lonely because they build walls instead of bridges.	1

SUMMARY

This thesis broadens current understanding of how location-based games can promote meaningful social interaction in citizens' own neighbourhoods. It investigates social cohesion and the role of social interaction to its promotion, delves into which requirements users have for playing in their neighbourhood and with its citizens, and takes a technical perspective into how this type of games should be designed to be successful at triggering interaction in public space. From this understanding, which stems from adolescents and adults from Rotterdam and The Hague, NL, a specific design and prototype of a location-based game is proposed and tested. This thesis addresses several gaps found in the current body of knowledge. On the one hand, meaningful interactions are person-dependent, can occur in various forms, and their impact on societies is not well understood. On the other hand, it is not well understood how to build location-based games for such aim: it is not known which requirements should be considered, attempts to build location-based games are often a product of in-house development not centred early on around users, no known guidelines exist for meaningful social interaction, and no consensus exists on what to consider when building location-based games from a technical perspective.

This thesis offers learnings on how to best design location-based games to promote interaction that matters to local communities. It firstly offers an overview of social cohesion and how multiple factors and actors have the power to influence local communities. It then argues that meaningful social interaction bears the power to break down stereotypes and prejudice, empowers people's agencies to act, has a positive impact on cohesion, emerges at people's own pace, and addresses conflict. From this, it dives into the preferences, needs and desires of adolescents and adults to better understand what sorts of interactions are meaningful to them. This thesis explores throughout several case studies the requirements that these target groups have, and advances gameplay dynamics and game activity types that location-based games should implement to be successful at inviting meaningful social interaction in public space. These case studies also research different sorts of interaction that each game activity type invites players to have, and elicit specific game ideas that are particularly tailored around perceived-to-be socially challenging neighbourhoods in The Netherlands. These case studies culminate in the recommendation of several guidelines to be used at different stages of the game design: gameplay requirements, guidelines for meaningful social interaction to occur in the studied groups, and the sorts of game activities that designers should include to invite specific forms of social interaction. This thesis also proposes a systems architecture with key architectural components, to drive consensus and inform on what to consider when building location-based games for this purpose from a technical perspective.

The lessons learned that are advanced in this thesis help practitioners design location-based games that are more tailored to what future players want to play, and help researchers understand what it means to design for meaningful social interaction in any public space around the world. Players have distinct preferences with regard to the ways they are ex-

posed to their own neighbourhood, and the forms of interaction they would rather experience. Understanding this, and incorporating such preferences in game design, lead to gameplay experiences that can have a positive effect on societies, as they have the power to promote interaction and positive relationships in local communities. These gameplay experiences invite individuals to come together and have meaningful interactions in a playful way, (re)engage with their own neighbourhood, and be part of their local community.

SAMENVATTING

Dit proefschrift verbreedt de huidige kennis van hoe digitale locatiegebaseerde games sociale interactie kunnen bevorderen, die belangrijk is voor burgers, in hun eigen buurt. Het onderzoekt de rol van sociale interactie voor het ontstaan van sociale cohesie, de voorwaarden die spelers stellen aan het spelen in hun buurt en met wie daar woont, en bekijkt vanuit een technisch perspectief hoe dit soort games ontworpen moeten worden om succesvol interactie teweeg te brengen in de openbare ruimte. Op basis van deze kennis, waaraan is bijgedragen door adolescenten en volwassenen uit Rotterdam en Den Haag, NL, wordt een specifiek ontwerp en prototype van een locatiegebaseerd game voorgesteld en getest.

Dit proefschrift behandelt verschillende hiaten in de huidige kennis. Allereerst zijn betekenisvolle interacties persoonsafhankelijk, kunnen ze in verschillende vormen voorkomen en wordt hun impact op samenlevingen niet goed begrepen. Tegelijkertijd wordt niet goed begrepen hoe locatiegebaseerde games voor een dergelijk doel moeten worden gebouwd: 1) het is niet bekend met welke voorwaarden rekening moet worden gehouden; 2) bij pogingen om locatiegebaseerde games te bouwen worden spelers meestal niet in een vroeg stadium van de ontwikkeling betrokken; 3) er zijn er geen richtlijnen bekend voor betekenisvolle sociale interactie; en 4) er is geen consensus over het bouwen van locatiegebaseerde games vanuit een technisch perspectief.

Dit proefschrift biedt inzichten voor het ontwerpen van locatiegebaseerde games die uitnodigen tot interactie, die belangrijk is voor lokale gemeenschappen. Het biedt ten eerste een overzicht van sociale cohesie en hoe meerdere factoren en actoren een rol spelen bij het beÃŕnvloeden van lokale gemeenschappen. Vervolgens wordt beargumenteerd dat betekenisvolle sociale interactie stereotypen en vooroordelen kan doorbreken; de agency van mensen om te handelen versterkt; een positieve invloed heeft op de sociale cohesie; en het mogelijk maakt om conflicten bespreekbaar te maken.

Op basis hiervan worden de voorkeuren, behoeften en verlangens van adolescenten en volwassenen besproken, om beter te begrijpen welke soorten interacties voor hen betekenisvol zijn. Dit proefschrift onderzoekt in verschillende casestudies de voorwaarden die deze doelgroepen stellen, en op basis van deze voorwaarden worden gameplay-dynamieken en types van game-activiteiten voorgesteld. Het implementeren van deze voorwaarden is essentieel voor het succesvol uitnodigen tot betekenisvolle sociale interactie in locatiegebaseerde games, in de openbare ruimte. De casestudy's onderzoeken ook verschillende soorten van interactie waartoe elk type gameactiviteit spelers uitnodigt, en verzamelt met name game ideeÃńn voor buurten in Nederland die als onveilig worden ervaren. Deze casestudy's resulteren in de aanbeveling van verschillende richtlijnen die in verschillende stadia van het game-ontwerp kunnen worden gebruikt: gameplay-voorwaarden, richtlijnen voor betekenisvolle sociale interactie die kan plaatsvinden in de bestudeerde groepen, en het soort game-activiteiten die ontwerpers zouden moeten opnemen om specifieke vormen van sociale interactie uit te nodigen. Dit proefschrift stelt ook een systeemarchitectuur voor met essentiÃńle architecturale componenten, voor specialisten, om consensus te bereiken bij het bouwen van deze locatiegebaseerde games, vanuit een technisch perspectief.

De inzichten in dit proefschrift helpen specialisten om locatiegebaseerde games te ontwerpen die meer zijn afgestemd op wat toekomstige spelers willen spelen, en helpen onderzoekers te begrijpen wat het betekent om te ontwerpen voor betekenisvolle sociale interactie in iedere openbare ruimte, in de hele wereld. Spelers hebben verschillende voorkeuren met betrekking tot de manier waarop ze worden blootgesteld aan hun eigen buurt, en de vormen van interactie die ze prefereren om te ervaren. Het opnemen van dergelijke voorkeuren in het ontwerp van games, leidt tot gameplay-ervaringen die een positief effect kunnen hebben op samenlevingen, aangezien ze de kracht hebben om interactie en positieve relaties in lokale gemeenschappen te bevorderen. Deze gameplay-ervaringen nodigen individuen uit om samen te komen en betekenisvolle interactie te ervaren, op een speelse manier, voor (hernieuwde) betrokkenheid bij hun eigen buurt en om deel uit te maken van hun lokale gemeenschap.

SIKS Dissertations Series

2011	01	Botond Cseke (RUN), Variational Algorithms for Bayesian Inference in Latent Gaussian Models
	02	Nick Tinnemeier (UU), Organizing Agent Organizations. Syntax and Operational Semantics of an Organization-Oriented Programming Language
	03	Jan Martijn van der Werf (TUE), Compositional Design and Verification of Component-Based Information Systems
	04	Hado van Hasselt (UU), Insights in Reinforcement Learning; Formal analysis and empirical evaluation of temporal-difference
	05	Bas van der Raadt (VU), Enterprise Architecture Coming of Age - Increasing the Performance of an Emerging Discipline.
	06	Yiwen Wang (TUE), Semantically-Enhanced Recommendations in Cultural Heritage
	07	Yujia Cao (UT), Multimodal Information Presentation for High Load Human Computer Interaction
	08	Nieske Vergunst (UU), BDI-based Generation of Robust Task-Oriented Dialogues
	09	Tim de Jong (OU), Contextualised Mobile Media for Learning
	10	Bart Bogaert (UvT), Cloud Content Contention
	11	Dhaval Vyas (UT), Designing for Awareness: An Experience-focused HCI Perspective
	12	Carmen Bratosin (TUE), Grid Architecture for Distributed Process Mining
	13	Xiaoyu Mao (UvT), Airport under Control. Multiagent Scheduling for Airport Ground Handling
	14	Milan Lovric (EUR), Behavioral Finance and Agent-Based Artificial Markets
	15	Marijn Koolen (UvA), The Meaning of Structure: the Value of Link Evidence for Information Retrieval
	16	Maarten Schadd (UM), Selective Search in Games of Different Complexity
	17	Jiyin He (UVA), Exploring Topic Structure: Coherence, Diversity and Relatedness
	18	Mark Ponsen (UM), Strategic Decision-Making in complex games
	19	Ellen Rusman (OU), The Mind's Eye on Personal Profiles
	20	Qing Gu (VU), Guiding service-oriented software engineering - A view-based approach
	21	Linda Terlouw (TUD), Modularization and Specification of Service-Oriented Systems
	22	Junte Zhang (UVA), System Evaluation of Archival Description and Access
	23	Wouter Weerkamp (UVA), Finding People and their Utterances in Social Media
	24	Herwin van Welbergen (UT), Behavior Generation for Interpersonal Coordination with Virtual Humans On Specifying, Scheduling and Realizing Multimodal Virtual Human Behavior

25 Syed Waqar ul Qounain Jaffry (VU), Analysis and Validation of Models for Trust Dynamics
26 Matthijs Aart Pontier (VU), Virtual Agents for Human Communication - Emotion Regulation and Involvement-Distance Trade-Offs in Embodied Conversational Agents and Robots
27 Aniel Bhulai (VU), Dynamic website optimization through autonomous management of design patterns
28 Rianne Kaptein (UVA), Effective Focused Retrieval by Exploiting Query Context and Document Structure
29 Faisal Kamiran (TUE), Discrimination-aware Classification
30 Egon van den Broek (UT), Affective Signal Processing (ASP): Unraveling the mystery of emotions
31 Ludo Waltman (EUR), Computational and Game-Theoretic Approaches for Modeling Bounded Rationality
32 Nees-Jan van Eck (EUR), Methodological Advances in Bibliometric Mapping of Science
33 Tom van der Weide (UU), Arguing to Motivate Decisions
34 Paolo Turrini (UU), Strategic Reasoning in Interdependence: Logical and Game-theoretical Investigations
35 Maaike Harbers (UU), Explaining Agent Behavior in Virtual Training
36 Erik van der Spek (UU), Experiments in serious game design: a cognitive approach
37 Adriana Burlutiu (RUN), Machine Learning for Pairwise Data, Applications for Preference Learning and Supervised Network Inference
38 Nyree Lemmens (UM), Bee-inspired Distributed Optimization
39 Joost Westra (UU), Organizing Adaptation using Agents in Serious Games
40 Viktor Clerc (VU), Architectural Knowledge Management in Global Software Development
41 Luan Ibraimi (UT), Cryptographically Enforced Distributed Data Access Control
42 Michal Sindlar (UU), Explaining Behavior through Mental State Attribution
43 Henk van der Schuur (UU), Process Improvement through Software Operation Knowledge
44 Boris Reuderink (UT), Robust Brain-Computer Interfaces
45 Herman Stehouwer (UvT), Statistical Language Models for Alternative Sequence Selection
46 Beibei Hu (TUD), Towards Contextualized Information Delivery: A Rule-based Architecture for the Domain of Mobile Police Work
47 Azizi Bin Ab Aziz (VU), Exploring Computational Models for Intelligent Support of Persons with Depression
48 Mark Ter Maat (UT), Response Selection and Turn-taking for a Sensitive Artificial Listening Agent
49 Andreea Niculescu (UT), Conversational interfaces for task-oriented spoken dialogues: design aspects influencing interaction quality

---

2012 01 Terry Kakeeto (UvT), Relationship Marketing for SMEs in Uganda
02 Muhammad Umair (VU), Adaptivity, emotion, and Rationality in Human and Ambient Agent Models

03 Adam Vanya (VU), Supporting Architecture Evolution by Mining Software Repositories
04 Jurriaan Souer (UU), Development of Content Management System-based Web Applications
05 Marijn Plomp (UU), Maturing Interorganisational Information Systems
06 Wolfgang Reinhardt (OU), Awareness Support for Knowledge Workers in Research Networks
07 Rianne van Lambalgen (VU), When the Going Gets Tough: Exploring Agent-based Models of Human Performance under Demanding Conditions
08 Gerben de Vries (UVA), Kernel Methods for Vessel Trajectories
09 Ricardo Neisse (UT), Trust and Privacy Management Support for Context-Aware Service Platforms
10 David Smits (TUE), Towards a Generic Distributed Adaptive Hypermedia Environment
11 J.C.B. Rantham Prabhakara (TUE), Process Mining in the Large: Preprocessing, Discovery, and Diagnostics
12 Kees van der Sluijs (TUE), Model Driven Design and Data Integration in Semantic Web Information Systems
13 Suleman Shahid (UvT), Fun and Face: Exploring non-verbal expressions of emotion during playful interactions
14 Evgeny Knutov (TUE), Generic Adaptation Framework for Unifying Adaptive Web-based Systems
15 Natalie van der Wal (VU), Social Agents. Agent-Based Modelling of Integrated Internal and Social Dynamics of Cognitive and Affective Processes.
16 Fiemke Both (VU), Helping people by understanding them - Ambient Agents supporting task execution and depression treatment
17 Amal Elgammal (UvT), Towards a Comprehensive Framework for Business Process Compliance
18 Eltjo Poort (VU), Improving Solution Architecting Practices
19 Helen Schonenberg (TUE), What's Next? Operational Support for Business Process Execution
20 Ali Bahramisharif (RUN), Covert Visual Spatial Attention, a Robust Paradigm for Brain-Computer Interfacing
21 Roberto Cornacchia (TUD), Querying Sparse Matrices for Information Retrieval
22 Thijs Vis (UvT), Intelligence, politie en veiligheidsdienst: verenigbare grootheden?
23 Christian Muehl (UT), Toward Affective Brain-Computer Interfaces: Exploring the Neurophysiology of Affect during Human Media Interaction
24 Laurens van der Werff (UT), Evaluation of Noisy Transcripts for Spoken Document Retrieval
25 Silja Eckartz (UT), Managing the Business Case Development in Inter-Organizational IT Projects: A Methodology and its Application
26 Emile de Maat (UVA), Making Sense of Legal Text
27 Hayrettin Gurkok (UT), Mind the Sheep! User Experience Evaluation & Brain-Computer Interface Games
28 Nancy Pascall (UvT), Engendering Technology Empowering Women
29 Almer Tigelaar (UT), Peer-to-Peer Information Retrieval

30 Alina Pommeranz (TUD), Designing Human-Centered Systems for Reflective Decision Making
31 Emily Bagarukayo (RUN), A Learning by Construction Approach for Higher Order Cognitive Skills Improvement, Building Capacity and Infrastructure
32 Wietske Visser (TUD), Qualitative multi-criteria preference representation and reasoning
33 Rory Sie (OUN), Coalitions in Cooperation Networks (COCOON)
34 Pavol Jancura (RUN), Evolutionary analysis in PPI networks and applications
35 Evert Haasdijk (VU), Never Too Old To Learn – On-line Evolution of Controllers in Swarm- and Modular Robotics
36 Denis Ssebugwawo (RUN), Analysis and Evaluation of Collaborative Modeling Processes
37 Agnes Nakakawa (RUN), A Collaboration Process for Enterprise Architecture Creation
38 Selmar Smit (VU), Parameter Tuning and Scientific Testing in Evolutionary Algorithms
39 Hassan Fatemi (UT), Risk-aware design of value and coordination networks
40 Agus Gunawan (UvT), Information Access for SMEs in Indonesia
41 Sebastian Kelle (OU), Game Design Patterns for Learning
42 Dominique Verpoorten (OU), Reflection Amplifiers in self-regulated Learning
43 Withdrawn
44 Anna Tordai (VU), On Combining Alignment Techniques
45 Benedikt Kratz (UvT), A Model and Language for Business-aware Transactions
46 Simon Carter (UVA), Exploration and Exploitation of Multilingual Data for Statistical Machine Translation
47 Manos Tsagkias (UVA), Mining Social Media: Tracking Content and Predicting Behavior
48 Jorn Bakker (TUE), Handling Abrupt Changes in Evolving Time-series Data
49 Michael Kaisers (UM), Learning against Learning - Evolutionary dynamics of reinforcement learning algorithms in strategic interactions
50 Steven van Kervel (TUD), Ontologogy driven Enterprise Information Systems Engineering
51 Jeroen de Jong (TUD), Heuristics in Dynamic Sceduling; a practical framework with a case study in elevator dispatching

---

2013 01 Viorel Milea (EUR), News Analytics for Financial Decision Support
02 Erietta Liarou (CWI), MonetDB/DataCell: Leveraging the Column-store Database Technology for Efficient and Scalable Stream Processing
03 Szymon Klarman (VU), Reasoning with Contexts in Description Logics
04 Chetan Yadati (TUD), Coordinating autonomous planning and scheduling
05 Dulce Pumareja (UT), Groupware Requirements Evolutions Patterns
06 Romulo Goncalves (CWI), The Data Cyclotron: Juggling Data and Queries for a Data Warehouse Audience
07 Giel van Lankveld (UvT), Quantifying Individual Player Differences
08 Robbert-Jan Merk (VU), Making enemies: cognitive modeling for opponent agents in fighter pilot simulators
09 Fabio Gori (RUN), Metagenomic Data Analysis: Computational Methods and Applications

10 Jeewanie Jayasinghe Arachchige (UvT), A Unified Modeling Framework for Service Design.
11 Evangelos Pournaras (TUD), Multi-level Reconfigurable Self-organization in Overlay Services
12 Marian Razavian (VU), Knowledge-driven Migration to Services
13 Mohammad Safiri (UT), Service Tailoring: User-centric creation of integrated IT-based homecare services to support independent living of elderly
14 Jafar Tanha (UVA), Ensemble Approaches to Semi-Supervised Learning Learning
15 Daniel Hennes (UM), Multiagent Learning - Dynamic Games and Applications
16 Eric Kok (UU), Exploring the practical benefits of argumentation in multi-agent deliberation
17 Koen Kok (VU), The PowerMatcher: Smart Coordination for the Smart Electricity Grid
18 Jeroen Janssens (UvT), Outlier Selection and One-Class Classification
19 Renze Steenhuizen (TUD), Coordinated Multi-Agent Planning and Scheduling
20 Katja Hofmann (UvA), Fast and Reliable Online Learning to Rank for Information Retrieval
21 Sander Wubben (UvT), Text-to-text generation by monolingual machine translation
22 Tom Claassen (RUN), Causal Discovery and Logic
23 Patricio de Alencar Silva (UvT), Value Activity Monitoring
24 Haitham Bou Ammar (UM), Automated Transfer in Reinforcement Learning
25 Agnieszka Anna Latoszek-Berendsen (UM), Intention-based Decision Support. A new way of representing and implementing clinical guidelines in a Decision Support System
26 Alireza Zarghami (UT), Architectural Support for Dynamic Homecare Service Provisioning
27 Mohammad Huq (UT), Inference-based Framework Managing Data Provenance
28 Frans van der Sluis (UT), When Complexity becomes Interesting: An Inquiry into the Information eXperience
29 Iwan de Kok (UT), Listening Heads
30 Joyce Nakatumba (TUE), Resource-Aware Business Process Management: Analysis and Support
31 Dinh Khoa Nguyen (UvT), Blueprint Model and Language for Engineering Cloud Applications
32 Kamakshi Rajagopal (OUN), Networking For Learning; The role of Networking in a Lifelong Learner's Professional Development
33 Qi Gao (TUD), User Modeling and Personalization in the Microblogging Sphere
34 Kien Tjin-Kam-Jet (UT), Distributed Deep Web Search
35 Abdallah El Ali (UvA), Minimal Mobile Human Computer Interaction
36 Than Lam Hoang (TUe), Pattern Mining in Data Streams
37 Dirk Börner (OUN), Ambient Learning Displays
38 Eelco den Heijer (VU), Autonomous Evolutionary Art
39 Joop de Jong (TUD), A Method for Enterprise Ontology based Design of Enterprise Information Systems

	40	Pim Nijssen (UM), Monte-Carlo Tree Search for Multi-Player Games
	41	Jochem Liem (UVA), Supporting the Conceptual Modelling of Dynamic Systems: A Knowledge Engineering Perspective on Qualitative Reasoning
	42	Léon Planken (TUD), Algorithms for Simple Temporal Reasoning
	43	Marc Bron (UVA), Exploration and Contextualization through Interaction and Concepts
2014	01	Nicola Barile (UU), Studies in Learning Monotone Models from Data
	02	Fiona Tuliyano (RUN), Combining System Dynamics with a Domain Modeling Method
	03	Sergio Raul Duarte Torres (UT), Information Retrieval for Children: Search Behavior and Solutions
	04	Hanna Jochmann-Mannak (UT), Websites for children: search strategies and interface design - Three studies on children's search performance and evaluation
	05	Jurriaan van Reijsen (UU), Knowledge Perspectives on Advancing Dynamic Capability
	06	Damian Tamburri (VU), Supporting Networked Software Development
	07	Arya Adriansyah (TUE), Aligning Observed and Modeled Behavior
	08	Samur Araujo (TUD), Data Integration over Distributed and Heterogeneous Data Endpoints
	09	Philip Jackson (UvT), Toward Human-Level Artificial Intelligence: Representation and Computation of Meaning in Natural Language
	10	Ivan Salvador Razo Zapata (VU), Service Value Networks
	11	Janneke van der Zwaan (TUD), An Empathic Virtual Buddy for Social Support
	12	Willem van Willigen (VU), Look Ma, No Hands: Aspects of Autonomous Vehicle Control
	13	Arlette van Wissen (VU), Agent-Based Support for Behavior Change: Models and Applications in Health and Safety Domains
	14	Yangyang Shi (TUD), Language Models With Meta-information
	15	Natalya Mogles (VU), Agent-Based Analysis and Support of Human Functioning in Complex Socio-Technical Systems: Applications in Safety and Healthcare
	16	Krystyna Milian (VU), Supporting trial recruitment and design by automatically interpreting eligibility criteria
	17	Kathrin Dentler (VU), Computing healthcare quality indicators automatically: Secondary Use of Patient Data and Semantic Interoperability
	18	Mattijs Ghijsen (UVA), Methods and Models for the Design and Study of Dynamic Agent Organizations
	19	Vinicius Ramos (TUE), Adaptive Hypermedia Courses: Qualitative and Quantitative Evaluation and Tool Support
	20	Mena Habib (UT), Named Entity Extraction and Disambiguation for Informal Text: The Missing Link
	21	Kassidy Clark (TUD), Negotiation and Monitoring in Open Environments
	22	Marieke Peeters (UU), Personalized Educational Games - Developing agent-supported scenario-based training
	23	Eleftherios Sidirourgos (UvA/CWI), Space Efficient Indexes for the Big Data Era
	24	Davide Ceolin (VU), Trusting Semi-structured Web Data

25 Martijn Lappenschaar (RUN), New network models for the analysis of disease interaction
26 Tim Baarslag (TUD), What to Bid and When to Stop
27 Rui Jorge Almeida (EUR), Conditional Density Models Integrating Fuzzy and Probabilistic Representations of Uncertainty
28 Anna Chmielowiec (VU), Decentralized k-Clique Matching
29 Jaap Kabbedijk (UU), Variability in Multi-Tenant Enterprise Software
30 Peter de Cock (UvT), Anticipating Criminal Behaviour
31 Leo van Moergestel (UU), Agent Technology in Agile Multiparallel Manufacturing and Product Support
32 Naser Ayat (UvA), On Entity Resolution in Probabilistic Data
33 Tesfa Tegegne (RUN), Service Discovery in eHealth
34 Christina Manteli (VU), The Effect of Governance in Global Software Development: Analyzing Transactive Memory Systems.
35 Joost van Ooijen (UU), Cognitive Agents in Virtual Worlds: A Middleware Design Approach
36 Joos Buijs (TUE), Flexible Evolutionary Algorithms for Mining Structured Process Models
37 Maral Dadvar (UT), Experts and Machines United Against Cyberbullying
38 Danny Plass-Oude Bos (UT), Making brain-computer interfaces better: improving usability through post-processing.
39 Jasmina Maric (UvT), Web Communities, Immigration, and Social Capital
40 Walter Omona (RUN), A Framework for Knowledge Management Using ICT in Higher Education
41 Frederic Hogenboom (EUR), Automated Detection of Financial Events in News Text
42 Carsten Eijckhof (CWI/TUD), Contextual Multidimensional Relevance Models
43 Kevin Vlaanderen (UU), Supporting Process Improvement using Method Increments
44 Paulien Meesters (UvT), Intelligent Blauw. Met als ondertitel: Intelligence-gestuurde politiezorg in gebiedsgebonden eenheden.
45 Birgit Schmitz (OUN), Mobile Games for Learning: A Pattern-Based Approach
46 Ke Tao (TUD), Social Web Data Analytics: Relevance, Redundancy, Diversity
47 Shangsong Liang (UVA), Fusion and Diversification in Information Retrieval

---

2015 01 Niels Netten (UvA), Machine Learning for Relevance of Information in Crisis Response
02 Faiza Bukhsh (UvT), Smart auditing: Innovative Compliance Checking in Customs Controls
03 Twan van Laarhoven (RUN), Machine learning for network data
04 Howard Spoelstra (OUN), Collaborations in Open Learning Environments
05 Christoph Bösch (UT), Cryptographically Enforced Search Pattern Hiding
06 Farideh Heidari (TUD), Business Process Quality Computation - Computing Non-Functional Requirements to Improve Business Processes
07 Maria-Hendrike Peetz (UvA), Time-Aware Online Reputation Analysis
08 Jie Jiang (TUD), Organizational Compliance: An agent-based model for designing and evaluating organizational interactions
09 Randy Klaassen (UT), HCI Perspectives on Behavior Change Support Systems

10 Henry Hermans (OUN), OpenU: design of an integrated system to support life-long learning
11 Yongming Luo (TUE), Designing algorithms for big graph datasets: A study of computing bisimulation and joins
12 Julie M. Birkholz (VU), Modi Operandi of Social Network Dynamics: The Effect of Context on Scientific Collaboration Networks
13 Giuseppe Procaccianti (VU), Energy-Efficient Software
14 Bart van Straalen (UT), A cognitive approach to modeling bad news conversations
15 Klaas Andries de Graaf (VU), Ontology-based Software Architecture Documentation
16 Changyun Wei (UT), Cognitive Coordination for Cooperative Multi-Robot Teamwork
17 André van Cleeff (UT), Physical and Digital Security Mechanisms: Properties, Combinations and Trade-offs
18 Holger Pirk (CWI), Waste Not, Want Not! - Managing Relational Data in Asymmetric Memories
19 Bernardo Tabuenca (OUN), Ubiquitous Technology for Lifelong Learners
20 Lois Vanhée (UU), Using Culture and Values to Support Flexible Coordination
21 Sibren Fetter (OUN), Using Peer-Support to Expand and Stabilize Online Learning
22 Zhemin Zhu (UT), Co-occurrence Rate Networks
23 Luit Gazendam (VU), Cataloguer Support in Cultural Heritage
24 Richard Berendsen (UVA), Finding People, Papers, and Posts: Vertical Search Algorithms and Evaluation
25 Steven Woudenberg (UU), Bayesian Tools for Early Disease Detection
26 Alexander Hogenboom (EUR), Sentiment Analysis of Text Guided by Semantics and Structure
27 Sándor Héman (CWI), Updating compressed colomn stores
28 Janet Bagorogoza (TiU), Knowledge Management and High Performance; The Uganda Financial Institutions Model for HPO
29 Hendrik Baier (UM), Monte-Carlo Tree Search Enhancements for One-Player and Two-Player Domains
30 Kiavash Bahreini (OU), Real-time Multimodal Emotion Recognition in E-Learning
31 Yakup Koç (TUD), On the robustness of Power Grids
32 Jerome Gard (UL), Corporate Venture Management in SMEs
33 Frederik Schadd (TUD), Ontology Mapping with Auxiliary Resources
34 Victor de Graaf (UT), Gesocial Recommender Systems
35 Jungxao Xu (TUD), Affective Body Language of Humanoid Robots: Perception and Effects in Human Robot Interaction

---

2016 01 Syed Saiden Abbas (RUN), Recognition of Shapes by Humans and Machines
02 Michiel Christiaan Meulendijk (UU), Optimizing medication reviews through decision support: prescribing a better pill to swallow
03 Maya Sappelli (RUN), Knowledge Work in Context: User Centered Knowledge Worker Support
04 Laurens Rietveld (VU), Publishing and Consuming Linked Data

05 Evgeny Sherkhonov (UVA), Expanded Acyclic Queries: Containment and an Application in Explaining Missing Answers
06 Michel Wilson (TUD), Robust scheduling in an uncertain environment
07 Jeroen de Man (VU), Measuring and modeling negative emotions for virtual training
08 Matje van de Camp (TiU), A Link to the Past: Constructing Historical Social Networks from Unstructured Data
09 Archana Nottamkandath (VU), Trusting Crowdsourced Information on Cultural Artefacts
10 George Karafotias (VUA), Parameter Control for Evolutionary Algorithms
11 Anne Schuth (UVA), Search Engines that Learn from Their Users
12 Max Knobbout (UU), Logics for Modelling and Verifying Normative Multi-Agent Systems
13 Nana Baah Gyan (VU), The Web, Speech Technologies and Rural Development in West Africa - An ICT4D Approach
14 Ravi Khadka (UU), Revisiting Legacy Software System Modernization
15 Steffen Michels (RUN), Hybrid Probabilistic Logics - Theoretical Aspects, Algorithms and Experiments
16 Guangliang Li (UVA), Socially Intelligent Autonomous Agents that Learn from Human Reward
17 Berend Weel (VU), Towards Embodied Evolution of Robot Organisms
18 Albert Meroño Peñuela (VU), Refining Statistical Data on the Web
19 Julia Efremova (Tu/e), Mining Social Structures from Genealogical Data
20 Daan Odijk (UVA), Context & Semantics in News & Web Search
21 Alejandro Moreno Célleri (UT), From Traditional to Interactive Playspaces: Automatic Analysis of Player Behavior in the Interactive Tag Playground
22 Grace Lewis (VU), Software Architecture Strategies for Cyber-Foraging Systems
23 Fei Cai (UVA), Query Auto Completion in Information Retrieval
24 Brend Wanders (UT), Repurposing and Probabilistic Integration of Data; An Iterative and data model independent approach
25 Julia Kiseleva (TU/e), Using Contextual Information to Understand Searching and Browsing Behavior
26 Dilhan Thilakarathne (VU), In or Out of Control: Exploring Computational Models to Study the Role of Human Awareness and Control in Behavioural Choices, with Applications in Aviation and Energy Management Domains
27 Wen Li (TUD), Understanding Geo-spatial Information on Social Media
28 Mingxin Zhang (TUD), Large-scale Agent-based Social Simulation - A study on epidemic prediction and control
29 Nicolas Höning (TUD), Peak reduction in decentralised electricity systems - Markets and prices for flexible planning
30 Ruud Mattheij (UvT), The Eyes Have It
31 Mohammad Khelghati (UT), Deep web content monitoring
32 Eelco Vriezekolk (UT), Assessing Telecommunication Service Availability Risks for Crisis Organisations
33 Peter Bloem (UVA), Single Sample Statistics, exercises in learning from just one example

34 Dennis Schunselaar (TUE), Configurable Process Trees: Elicitation, Analysis, and Enactment
35 Zhaochun Ren (UVA), Monitoring Social Media: Summarization, Classification and Recommendation
36 Daphne Karreman (UT), Beyond R2D2: The design of nonverbal interaction behavior optimized for robot-specific morphologies
37 Giovanni Sileno (UvA), Aligning Law and Action - a conceptual and computational inquiry
38 Andrea Minuto (UT), Materials that Matter - Smart Materials meet Art & Interaction Design
39 Merijn Bruijnes (UT), Believable Suspect Agents; Response and Interpersonal Style Selection for an Artificial Suspect
40 Christian Detweiler (TUD), Accounting for Values in Design
41 Thomas King (TUD), Governing Governance: A Formal Framework for Analysing Institutional Design and Enactment Governance
42 Spyros Martzoukos (UVA), Combinatorial and Compositional Aspects of Bilingual Aligned Corpora
43 Saskia Koldijk (RUN), Context-Aware Support for Stress Self-Management: From Theory to Practice
44 Thibault Sellam (UVA), Automatic Assistants for Database Exploration
45 Bram van de Laar (UT), Experiencing Brain-Computer Interface Control
46 Jorge Gallego Perez (UT), Robots to Make you Happy
47 Christina Weber (UL), Real-time foresight - Preparedness for dynamic innovation networks
48 Tanja Buttler (TUD), Collecting Lessons Learned
49 Gleb Polevoy (TUD), Participation and Interaction in Projects. A Game-Theoretic Analysis
50 Yan Wang (UVT), The Bridge of Dreams: Towards a Method for Operational Performance Alignment in IT-enabled Service Supply Chains

---

2017 01 Jan-Jaap Oerlemans (UL), Investigating Cybercrime
02 Sjoerd Timmer (UU), Designing and Understanding Forensic Bayesian Networks using Argumentation
03 Daniël Harold Telgen (UU), Grid Manufacturing; A Cyber-Physical Approach with Autonomous Products and Reconfigurable Manufacturing Machines
04 Mrunal Gawade (CWI), Multi-core Parallelism in a Column-store
05 Mahdieh Shadi (UVA), Collaboration Behavior
06 Damir Vandic (EUR), Intelligent Information Systems for Web Product Search
07 Roel Bertens (UU), Insight in Information: from Abstract to Anomaly
08 Rob Konijn (VU) , Detecting Interesting Differences:Data Mining in Health Insurance Data using Outlier Detection and Subgroup Discovery
09 Dong Nguyen (UT), Text as Social and Cultural Data: A Computational Perspective on Variation in Text
10 Robby van Delden (UT), (Steering) Interactive Play Behavior
11 Florian Kunneman (RUN), Modelling patterns of time and emotion in Twitter #anticipointment
12 Sander Leemans (TUE), Robust Process Mining with Guarantees
13 Gijs Huisman (UT), Social Touch Technology - Extending the reach of social touch through haptic technology

14 Shoshannah Tekofsky (UvT), You Are Who You Play You Are: Modelling Player Traits from Video Game Behavior
15 Peter Berck (RUN), Memory-Based Text Correction
16 Aleksandr Chuklin (UVA), Understanding and Modeling Users of Modern Search Engines
17 Daniel Dimov (UL), Crowdsourced Online Dispute Resolution
18 Ridho Reinanda (UVA), Entity Associations for Search
19 Jeroen Vuurens (UT), Proximity of Terms, Texts and Semantic Vectors in Information Retrieval
20 Mohammadbashir Sedighi (TUD), Fostering Engagement in Knowledge Sharing: The Role of Perceived Benefits, Costs and Visibility
21 Jeroen Linssen (UT), Meta Matters in Interactive Storytelling and Serious Gaming (A Play on Worlds)
22 Sara Magliacane (VU), Logics for causal inference under uncertainty
23 David Graus (UVA), Entities of Interest — Discovery in Digital Traces
24 Chang Wang (TUD), Use of Affordances for Efficient Robot Learning
25 Veruska Zamborlini (VU), Knowledge Representation for Clinical Guidelines, with applications to Multimorbidity Analysis and Literature Search
26 Merel Jung (UT), Socially intelligent robots that understand and respond to human touch
27 Michiel Joosse (UT), Investigating Positioning and Gaze Behaviors of Social Robots: People's Preferences, Perceptions and Behaviors
28 John Klein (VU), Architecture Practices for Complex Contexts
29 Adel Alhuraibi (UvT), From IT-BusinessStrategic Alignment to Performance: A Moderated Mediation Model of Social Innovation, and Enterprise Governance of IT"
30 Wilma Latuny (UvT), The Power of Facial Expressions
31 Ben Ruijl (UL), Advances in computational methods for QFT calculations
32 Thaer Samar (RUN), Access to and Retrievability of Content in Web Archives
33 Brigit van Loggem (OU), Towards a Design Rationale for Software Documentation: A Model of Computer-Mediated Activity
34 Maren Scheffel (OU), The Evaluation Framework for Learning Analytics
35 Martine de Vos (VU), Interpreting natural science spreadsheets
36 Yuanhao Guo (UL), Shape Analysis for Phenotype Characterisation from High-throughput Imaging
37 Alejandro Montes Garcia (TUE), WiBAF: A Within Browser Adaptation Framework that Enables Control over Privacy
38 Alex Kayal (TUD), Normative Social Applications
39 Sara Ahmadi (RUN), Exploiting properties of the human auditory system and compressive sensing methods to increase noise robustness in ASR
40 Altaf Hussain Abro (VUA), Steer your Mind: Computational Exploration of Human Control in Relation to Emotions, Desires and Social Support For applications in human-aware support systems
41 Adnan Manzoor (VUA), Minding a Healthy Lifestyle: An Exploration of Mental Processes and a Smart Environment to Provide Support for a Healthy Lifestyle
42 Elena Sokolova (RUN), Causal discovery from mixed and missing data with applications on ADHD datasets

	43	Maaike de Boer (RUN), Semantic Mapping in Video Retrieval
	44	Garm Lucassen (UU), Understanding User Stories - Computational Linguistics in Agile Requirements Engineering
	45	Bas Testerink (UU), Decentralized Runtime Norm Enforcement
	46	Jan Schneider (OU), Sensor-based Learning Support
	47	Jie Yang (TUD), Crowd Knowledge Creation Acceleration
	48	Angel Suarez (OU), Collaborative inquiry-based learning
2018	01	Han van der Aa (VUA), Comparing and Aligning Process Representations
	02	Felix Mannhardt (TUE), Multi-perspective Process Mining
	03	Steven Bosems (UT), Causal Models For Well-Being: Knowledge Modeling, Model-Driven Development of Context-Aware Applications, and Behavior Prediction
	04	Jordan Janeiro (TUD), Flexible Coordination Support for Diagnosis Teams in Data-Centric Engineering Tasks
	05	Hugo Huurdeman (UVA), Supporting the Complex Dynamics of the Information Seeking Process
	06	Dan Ionita (UT), Model-Driven Information Security Risk Assessment of Socio-Technical Systems
	07	Jieting Luo (UU), A formal account of opportunism in multi-agent systems
	08	Rick Smetsers (RUN), Advances in Model Learning for Software Systems
	09	Xu Xie (TUD), Data Assimilation in Discrete Event Simulations
	10	Julienka Mollee (VUA), Moving forward: supporting physical activity behavior change through intelligent technology
	11	Mahdi Sargolzaei (UVA), Enabling Framework for Service-oriented Collaborative Networks
	12	Xixi Lu (TUE), Using behavioral context in process mining
	13	Seyed Amin Tabatabaei (VUA), Computing a Sustainable Future
	14	Bart Joosten (UVT), Detecting Social Signals with Spatiotemporal Gabor Filters
	15	Naser Davarzani (UM), Biomarker discovery in heart failure
	16	Jaebok Kim (UT), Automatic recognition of engagement and emotion in a group of children
	17	Jianpeng Zhang (TUE), On Graph Sample Clustering
	18	Henriette Nakad (UL), De Notaris en Private Rechtspraak
	19	Minh Duc Pham (VUA), Emergent relational schemas for RDF
	20	Manxia Liu (RUN), Time and Bayesian Networks
	21	Aad Slootmaker (OUN), EMERGO: a generic platform for authoring and playing scenario-based serious games
	22	Eric Fernandes de Mello Araujo (VUA), Contagious: Modeling the Spread of Behaviours, Perceptions and Emotions in Social Networks
	23	Kim Schouten (EUR), Semantics-driven Aspect-Based Sentiment Analysis
	24	Jered Vroon (UT), Responsive Social Positioning Behaviour for Semi-Autonomous Telepresence Robots
	25	Riste Gligorov (VUA), Serious Games in Audio-Visual Collections
	26	Roelof Anne Jelle de Vries (UT),Theory-Based and Tailor-Made: Motivational Messages for Behavior Change Technology

27 Maikel Leemans (TUE), Hierarchical Process Mining for Scalable Software Analysis
28 Christian Willemse (UT), Social Touch Technologies: How they feel and how they make you feel
29 Yu Gu (UVT), Emotion Recognition from Mandarin Speech
30 Wouter Beek, The "K" in "semantic web" stands for "knowledge": scaling semantics to the web

---

2019 01 Rob van Eijk (UL),Web privacy measurement in real-time bidding systems. A graph-based approach to RTB system classification
02 Emmanuelle Beauxis Aussalet (CWI, UU), Statistics and Visualizations for Assessing Class Size Uncertainty
03 Eduardo Gonzalez Lopez de Murillas (TUE), Process Mining on Databases: Extracting Event Data from Real Life Data Sources
04 Ridho Rahmadi (RUN), Finding stable causal structures from clinical data
05 Sebastiaan van Zelst (TUE), Process Mining with Streaming Data
06 Chris Dijkshoorn (VU), Nichesourcing for Improving Access to Linked Cultural Heritage Datasets
07 Soude Fazeli (TUD), Recommender Systems in Social Learning Platforms
08 Frits de Nijs (TUD), Resource-constrained Multi-agent Markov Decision Processes
09 Fahimeh Alizadeh Moghaddam (UVA), Self-adaptation for energy efficiency in software systems
10 Qing Chuan Ye (EUR), Multi-objective Optimization Methods for Allocation and Prediction
11 Yue Zhao (TUD), Learning Analytics Technology to Understand Learner Behavioral Engagement in MOOCs
12 Jacqueline Heinerman (VU), Better Together
13 Guanliang Chen (TUD), MOOC Analytics: Learner Modeling and Content Generation
14 Daniel Davis (TUD), Large-Scale Learning Analytics: Modeling Learner Behavior & Improving Learning Outcomes in Massive Open Online Courses
15 Erwin Walraven (TUD), Planning under Uncertainty in Constrained and Partially Observable Environments
16 Guangming Li (TUE), Process Mining based on Object-Centric Behavioral Constraint (OCBC) Models
17 Ali Hurriyetoglu (RUN),Extracting actionable information from microtexts
18 Gerard Wagenaar (UU), Artefacts in Agile Team Communication
19 Vincent Koeman (TUD), Tools for Developing Cognitive Agents
20 Chide Groenouwe (UU), Fostering technically augmented human collective intelligence
21 Cong Liu (TUE), Software Data Analytics: Architectural Model Discovery and Design Pattern Detection
22 Martin van den Berg (VU),Improving IT Decisions with Enterprise Architecture
23 Qin Liu (TUD), Intelligent Control Systems: Learning, Interpreting, Verification
24 Anca Dumitrache (VU), Truth in Disagreement - Crowdsourcing Labeled Data for Natural Language Processing
25 Emiel van Miltenburg (VU), Pragmatic factors in (automatic) image description

26 Prince Singh (UT), An Integration Platform for Synchromodal Transport
27 Alessandra Antonaci (OUN), The Gamification Design Process applied to (Massive) Open Online Courses
28 Esther Kuindersma (UL), Cleared for take-off: Game-based learning to prepare airline pilots for critical situations
29 Daniel Formolo (VU), Using virtual agents for simulation and training of social skills in safety-critical circumstances
30 Vahid Yazdanpanah (UT), Multiagent Industrial Symbiosis Systems
31 Milan Jelisavcic (VU), Alive and Kicking: Baby Steps in Robotics
32 Chiara Sironi (UM), Monte-Carlo Tree Search for Artificial General Intelligence in Games
33 Anil Yaman (TUE), Evolution of Biologically Inspired Learning in Artificial Neural Networks
34 Negar Ahmadi (TUE), EEG Microstate and Functional Brain Network Features for Classification of Epilepsy and PNES
35 Lisa Facey-Shaw (OUN), Gamification with digital badges in learning programming
36 Kevin Ackermans (OUN), Designing Video-Enhanced Rubrics to Master Complex Skills
37 Jian Fang (TUD), Database Acceleration on FPGAs
38 Akos Kadar (OUN), Learning visually grounded and multilingual representations

---

2020 01 Armon Toubman (UL), Calculated Moves: Generating Air Combat Behaviour
02 Marcos de Paula Bueno (UL), Unraveling Temporal Processes using Probabilistic Graphical Models
03 Mostafa Deghani (UvA), Learning with Imperfect Supervision for Language Understanding
04 Maarten van Gompel (RUN), Context as Linguistic Bridges
05 Yulong Pei (TUE), On local and global structure mining
06 Preethu Rose Anish (UT), Stimulation Architectural Thinking during Requirements Elicitation - An Approach and Tool Support
07 Wim van der Vegt (OUN), Towards a software architecture for reusable game components
08 Ali Mirsoleimani (UL),Structured Parallel Programming for Monte Carlo Tree Search
09 Myriam Traub (UU), Measuring Tool Bias and Improving Data Quality for Digital Humanities Research
10 Alifah Syamsiyah (TUE), In-database Preprocessing for Process Mining
11 Sepideh Mesbah (TUD), Semantic-Enhanced Training Data Augmentation-Methods for Long-Tail Entity Recognition Models
12 Ward van Breda (VU), Predictive Modeling in E-Mental Health: Exploring Applicability in Personalised Depression Treatment
13 Marco Virgolin (CWI), Design and Application of Gene-pool Optimal Mixing Evolutionary Algorithms for Genetic Programming
14 Mark Raasveldt (CWI/UL), Integrating Analytics with Relational Databases
15 Konstantinos Georgiadis (OUN), Smart CAT: Machine Learning for Configurable Assessments in Serious Games
16 Ilona Wilmont (RUN), Cognitive Aspects of Conceptual Modelling

	17	Daniele Di Mitri (OUN), The Multimodal Tutor: Adaptive Feedback from Multimodal Experiences
	18	Georgios Methenitis (TUD), Agent Interactions & Mechanisms in Markets with Uncertainties: Electricity Markets in Renewable Energy Systems
	19	Guido van Capelleveen (UT), Industrial Symbiosis Recommender Systems
	20	Albert Hankel (VU), Embedding Green ICT Maturity in Organisations
	21	Karine da Silva Miras de Araujo (VU), Where is the robot?: Life as it could be
	22	Maryam Masoud Khamis (RUN), Understanding complex systems implementation through a modeling approach: the case of e-government in Zanzibar
	23	Rianne Conijn (UT), The Keys to Writing: A writing analytics approach to studying writing processes using keystroke logging
	24	Lenin da Nobrega Medeiros (VUA/RUN), How are you feeling, human? Towards emotionally supportive chatbots
	25	Xin Du (TUE), The Uncertainty in Exceptional Model Mining
	26	Krzysztof Leszek Sadowski (UU), GAMBIT: Genetic Algorithm for Model-Based mixed-Integer opTimization
	27	Ekaterina Muravyeva (TUD), Personal data and informed consent in an educational context
	28	Bibeg Limbu (TUD), Multimodal interaction for deliberate practice: Training complex skills with augmented reality
	29	Ioan Gabriel Bucur (RUN), Being Bayesian about Causal Inference
	30	Bob Zadok Blok (UL), Creatief, Creatieve, Creatiefst
	31	Gongjin Lan (VU), Learning better – From Baby to Better
	32	Jason Rhuggenaath (TUE), Revenue management in online markets: pricing and online advertising
	33	Rick Gilsing (TUE), Supporting service-dominant business model evaluation in the context of business model innovation
	34	Anna Bon (MU), Intervention or Collaboration? Redesigning Information and Communication Technologies for Development
2021	01	Francisco Xavier Dos Santos Fonseca (TUD), Location-based Games for Social Interaction in Public Space

About the Author

Xavier Fonseca is a software engineer that aims for positive impact in society through IT-based solutions. He is driven by research and innovation, and actively seeks for ways to build technology that can be created from underlying values such as social responsibility, privacy, and high performance. He leverages on knowledge gathered through years of programming experience, to tackles on real-world complex problems.

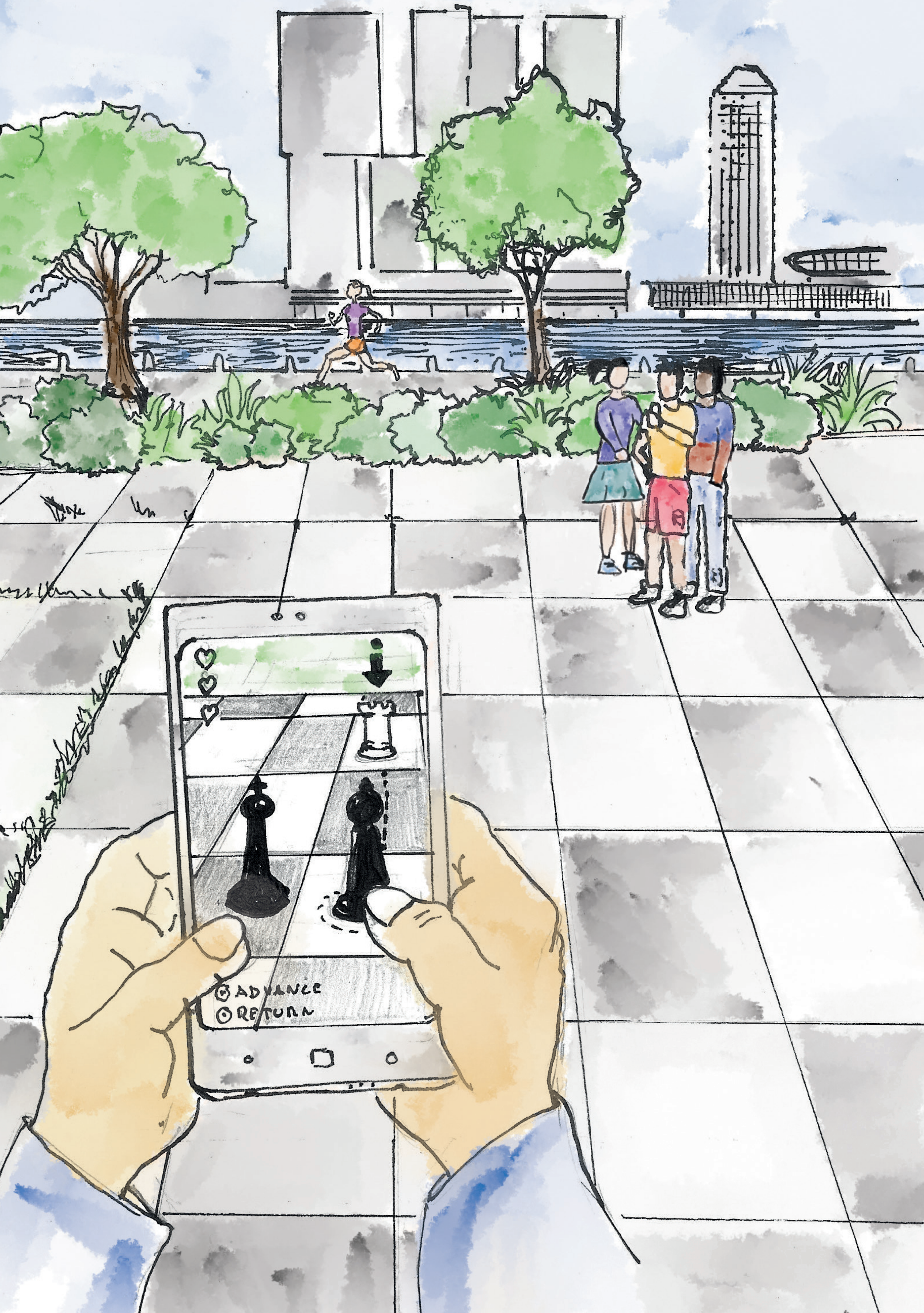
Xavier has co-authored multiple articles in top scientific journals and has presented his work at several national and international conferences. The topics he has addressed are on social cohesion, meaningful social interaction, playable cities, requirements engineering, user profiling, civic engagement, location-based games, serious digital games, games for education, and high performance computing to speed up artificial intelligence-based sequential algorithms (with the use of general purpose GPUs). Besides his scientific presentations, he also gave presentations as keynote speaker to other research groups about his work on social cohesion, to help define further research questions.

Xavier graduated with masters from the University of Aveiro, on Computer and Telecommunications Engineering. Soon after completing his studies, and throughout the following decade, he exposed himself to a variety of international experiences ranging from Portugal to India, Germany, and The Netherlands, where he provided consultancy services and began his career on research and innovation. A major part of this work was held on the field of high-performance computing, where he used general purpose GPUs to parallelize and accelerate existent sequential algorithms ranging from the medical domain (capsule endoscopy) to chemistry (mass spectrometry).

Xavier also completed a post graduation program on Industrial Information Systems from the Nova University of Lisbon, specifically on Cyber Physical Systems and the Internet of Things. In this post graduation, he acquired skills on embedded middlewares for IoT, identified the visions for its future, analysed communication technologies, and researched different hardware micro controllers and operating systems.

This hands-on experience, together with the drive to positively impact society, led Xavier to pursue a PhD on engineering technologies for a responsible digital future. In this research project, he focused on participatory information systems, IoT-based technology (Nervous-Net research project), and game design, as a positive approach to the lack of social cohesion in perceived-to-be challenging neighbourhoods of The Netherlands. This thesis is the result thereof.

For the future, Xavier wants to explore opportunities where he can grow into coordination of innovation and R&D initiatives. This ideally happens within the intersection of academy and industry, where he can begin his journey on coordination and implementation of R&D projects, management of R&D teams, guidance of junior researchers, and participation in the dissemination of science and innovation. Ethically innovative projects, conducted in a collaborative working environment for positive change, are his mission.


ADVANCE
RETURN