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Designing for meaningful social interaction in digital serious games

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Abstract

Digital serious games have shown to be effective in promoting citizen engagement and social interaction. The reasons for their success are, however, unknown. This paper proposes design recommendations to support designers of serious games for meaningful social interaction, based on player preferences, needs and desires, based on literature study and a case study for which a location-based game framework was designed, developed and evaluated. The case study with and for children/teenagers in Rotterdam focussed on the design of challenges by the children/teenagers for meaningful interaction with their environment, and the strengthening of their engagement with their own neighbourhood. The paper focuses specifically on: 1) if and when meaningful social interaction occurred during game play, how it occurred, and with which impact, and 2) the design choices/features that contributed to (the experience of) meaningful social interaction. On the basis of these results and the literature this paper proposes design recommendations to support designers of serious games for meaningful social interaction, taking not only the current players' needs and desires into account but also those of future players.

Keywords: Serious games; social interaction; meaningfulness.

1. Introduction

Social interaction is an exchange between individuals and is a building block of society [1]. Social interaction has shown to be particularly effective at tackling societal barriers such as lack of well-being, sense of "not belonging" to a community, or simply the lack of engagement with the neighbourhood [2]. This is the case particularly when interaction is pursued in a local context, where it becomes meaningful due to citizens working together [3, 4]. Meaningful interaction has shown to provide a means to approach diversity, increase quality of life, and influence the resilience of society [4, 5]. Meaningful experiences can be positive or negative [6, 7], and many factors affect the degree of significance such experiences have on the person/people involved [6, 8, 9]. This paper considers only the experiences that are positive, because social interaction, when positively 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 [2]. As such, with *meaningfulness*, this paper refers to *an overall enjoyable experience for a player, and enjoyable or neutral for individuals involved in the gameplay*.

Digitally supported, fun-based social experiences and exchanges can be designed to initiate such interaction, for example through serious games [10-18]. Serious games can be fun and engaging, bring people together through location-based experiences, and bring players in contact both with other people and with their own environment [19-24]. The reasons for the success of serious games designed to increase social interaction [10-18] are, however, unknown. There is little literature on how and why design choices [25] are made and how they affect player behaviour [10, 18, 26]. As a result there are also no design guidelines for serious games for meaningful social interaction.

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 [4, 18, 24, 27, 28]. 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 paper reports on a case study for which a location-based game framework was designed and developed with and for children/teenagers in the 10-16 age group in Rotterdam. The game focuses on strengthening their engagement with their own neighbourhood through meaningful social interaction. In this case study, the requirements, design process, and choices made during the design of the game are made explicit, and their effect evaluated during/after game play with the children/teenagers.

The paper focuses specifically on: 1) if and when meaningful social interaction occurred during game play, how it occurred, and with which impact, and 2) the design choices/features that contributed to (the experience of) meaningful social interaction. On the basis of these results (and the literature) this paper proposes design recommendations to support designers of serious games for meaningful social interaction [29-33], which aim at being a step towards future design guidelines.

The current state of the art on design guidelines for serious games is the focus of Section 2. Section 3 describes the context within which the case study was performed, Section 5 the experimental design, Section 6 the quantitative and qualitative results, and the analysis of these results. Section 7 discusses the results, proposes first design recommendations, and refers to the limitations of the study.

2. Literature Review

Over the past decades, technology has been turning cities around the world into smart urban environments [34]. Research projects have explored ways to foster citizen participation [35], and this has been done through mobile applications and other forms of technology [36-40] that support different types of social interaction. Games have shown to be able to turn neighbourhoods into playful environments, in which citizens engage with the public space and others in their own surroundings [24]. Such games can foster play and participation of citizens, nurture bonding and social relations [4, 19, 41, 42], and are capable of inciting behavioural change, regardless of the domain of application or goal (e.g. entertainment, competition, or education) [25]. 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 [25, 43, 44]. Despite attempts to understand the effects of individual game elements [43, 45], through theories and methods of analysis of games [43, 46-49], it is, as yet, still unclear which design choices lead to which behaviour/behavioural change [25, 50]. 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) [25, 51-54].

Motivation and behavioural change has shown to be achieved via numerous combinations of game elements (e.g. graphics, rules, a storyline, or levels) [55], and via more complex game mechanics and dynamics that are only observable during game play mediated by the game [47]. 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 [43]. 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 [18, 40].

Researchers have been in pursuit of such understanding by focusing on highly specific case studies, and then trying to generalize their findings to serious games. Such knowledge includes the values that designers should have in mind when designing games for purpose [43, 45, 56-60], the applicability of games in specific domains

[25, 61, 62], and even design guidelines to help researchers design and develop serious games for specific domains that are most often successful [63-65]. 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 [43], to values such as fun [45], play and playful experiences [56, 57], motivation [58], emotional fulfilment [59], and learning [60]. These values are essential for responsible design, in particular when designing for meaningful social interaction for civic engagement.

Regarding the design guidelines for serious games, literature shows that there are general guidelines, for example, as proposed by Laamarti et al. [66], and domain specific guidelines, for example for exergames for elderly users [63], authentication [64], stakeholders and policymakers [65], education [67-69], pervasive mobile games [16], collaborative multiplayer serious games [70], and health rehabilitation [71]. These guidelines differ: some are very domain specific, others generic. In exergames for elderly users, as an example, interaction mechanisms that enable navigation while standing and sitting, avoid excessive or sudden movements, with levels of adjustability (e.g. difficulty, or game speed), and simple interaction mechanisms to avoid frustration [63] are proposed. Guidelines for games for education are more generic, often building on Gargné et al.'s events of instruction [72], and indicating the need for integration with a school's educational curriculum [67] and a specific educational scenario [68, 69]. Guidelines for pervasive mobile games proposed in [16] are also generic: games should provide a perception of the current context, an equal chance to play, adjustable play sessions, and facilitate communication outside the game world.

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 although serious games have been developed for social interaction the design choices including their rationale for games developed for such experiments[1][2][3][4][5][6] [10-17] are rarely made explicit. There are a few exceptions. In the *Koppelkiek* game[1], design choices were based on an in-house idea generation process, complemented with results from a field study. The game *Mythical: The Mobile Awakening* [16] was purposefully designed to create a set of design guidelines for asynchronous pervasive mobile games with specific game elements such as contextual information, asynchronous game play, and predefined interval updates to explore the effect of time design on engagement. A number of design choices made by the designers of *City Conqueror* [17] to study the impact of location-based games on user perception of their environment, such as "no story line such as in *Pokémon GO"*, a real map of the city, and the turn-based game mechanic, are documented but not analysed.

As indicated above designing for meaningful social interaction requires consideration of player preferences, needs and requirements, to support interaction that is desired and meaningful to those interacting, including playful behaviour with the environment and others in their surroundings [4, 18, 24, 27, 28]. Inclusion of future players during design would seem essential. This paper explores a design process for a serious game for meaningful social interaction designed for children/teenagers, on the basis of which first design recommendations are formulated. This is done from the perspective of what children/teenagers believe to be meaningful to them in social interaction in public spaces.

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[1] https://whatsthehubbub.nl/projects/koppelkiek/, Koppelkiek, 'couple snapshot' in Dutch, last visited on 29th Jun. 2020.

[2] http://www.hellolamppost.co.uk/, Hello Lamp Post, The playful, city wide system that lets you talk to street furniture, last visited on 29th Jun. 2020.

[3] https://www.giantbomb.com/shadow-cities/3030-35591/, Shadow Cities, last visited on 29th Jun. 2020.

[4] https://itunes.apple.com/us/app/field-trip/id567841460?mt=8, Field Trip, last visited on 29th Jun. 2020.

[5] http://www.freewarepocketpc.net/ppc-download-feeding-yoshi-v1-2.html, Feeding Yoshi v1.2, last visited on 29th Jun. 2020.

[6] https://www.geocaching.com/play, Geocaching, last visited on 29th Jun. 2020.

3. Research Context

Meaningful social interaction is essential to civic engagement, that, in turn influences local social cohesion [2]. Research on social cohesion argues that three types of actors are of importance to social cohesion: the individual, the community, and formal institutions [4]. Different actors have both formally and informally contributed to the research project on which this paper reports during different phases: the Municipality of The Hague and the Dutch police, a cultural "Think Tank", primary and secondary schools, citizens in the neighbourhood linked to the schools, the Veldacademie (design studio) and university researchers. This project is situated in the southern part of Rotterdam in the Netherlands, in the districts Feijenoord and Tarwewijk, challenged by substantial crime and social undermining [73], transient nature of population, and ethnical diversity (with less than 40% being native Dutch[7]). Local partners agree with the "positive" approach of introducing a serious game to involve local citizens in interaction with the neighbourhood and their neighbours, to strengthen the local levels of cohesion. The choice to focus on children/teenagers was based on the promise of the future: they are the future.

To explore a way to create meaningful social interaction, future players and their requirements were involved in the design process [29-33]. A participatory design approach was chosen involving children/teenagers from the age group of 10-16 years of age for: 1) elicitation of requirements from the children [18, 27], 2) game development [24, 28], 3) content creation with and for children/teenagers , and 4) game play testing with children/teenagers (this paper).

Step 1: Requirements for serious games fostering social interaction

During workshops held at 2 secondary schools [27] in district of Feijenoord, preferences, needs, and desires of children/teenagers were elicited in a co-creation process in which they playfully designed game concepts. The game dynamics in these game concepts were analysed [18], discussed with the children, and prioritized (based on the number of participants that consider them to be of importance, and the degree to which), resulting in a sorted list of requirements depicted in Table 1.

Table 1: Game dynamics as requirements, sorted according to their degree of importance to children [18], highest first.

Requirement	**Description (shortened)**
Achievement	Sense of accomplishment, as an individual or a group, resulting from task completion.
Real-world play	Merge play with the physical environment and allow the player to be physically active.
Reinforcement	Foster play and engagement, e.g. a reward given for a certain action.
Social Interaction	Establish face-to-face communication with players or people not playing the game.
Collaboration	Shared goal by working together; may be necessary to further the game play.
Digital Interaction	Digital communication or any digital influence of the game play of players by a player.
Ownership	Players bring content to the game, and influence other player's game play.
Winning Condition	Competition between players, or player and game. Conditions to complete game tasks.
Collection	Collect items in the game environment (either digital or real world).
Exertion	Activities or game challenges involving physical effort to be solved.
Virtual Representation	Digitally represent the player's state, visibility, or social status.
Mission	Fantasy and overall purpose to the game play: a tale, narrative, or smaller missions.
Community Contribution	Positive consequences of the game play in the rhythm of the neighbourhood.
Lottery	Add surprise through random events that affect the game play or its outcome.

[7] https://www.ggdrotterdamrijnmond.nl/wat-doet-de-ggd/onderzoek/GGD_Factsheet_eenzaamheid_juli_2014.pdf, Fact Sheet, last visited on 29th Jun. 2020.

Step 2: Secrets of the South, a game created with and for children

Based on the requirements from Table 1, the serious game "Secrets of the South" (SotS) been developed. The description of the SotS follows in the next section.

Step 3: Types of activities that children want to do

After the initial iteration in the development of the game, children were again involved in its conceptualization to understand the types of challenges in which they were interested. Three distinct routes of approximately 1.4 kilometres in length, shown in Figure 2, were created starting from a primary school in the area (Tarwewijk). Researchers walked these with the children while conversing with them about possible activities to do and where, and, in the end, almost 50 location-based game ideas were proposed by the children in interaction with each other. SotS was extended with functionality to support the 7 types of challenges that emerged: Athlete, Inventor, Detective, Explorer, Hunter, Artist, and Volunteer. These types of challenges accommodate all of the activities the children proposed, as described in Table 2.

Table 2: Types of challenges that children proposed for the SotS game.

Type	Description
Artist	Player(s) are asked to design artwork in and about their neighbourhood (e.g. doing a musical performance on the street).
Athlete	This type requires physical activity to be solved (e.g. carry a bag or pick up trash), or a physical performance (e.g. see who can finish the free-running the fastest).
Detective	Players have to find information and answer questions about factual knowledge, such as asking people about local heroes.
Explorer	Players explore their neighbourhood and comprehend more about the location or people living there (e.g. discover an unknown building, or local hero), by engaging with either the environment or random people.
Hunter	Players have to find specific people or tangible objects (e.g. find the person responsible for the community centre, or find a QR code that enables players to still solve the challenge if that person is not around).
Inventor	Players propose new ideas to address an issue or improve the neighbourhood (e.g. designing a new playground).
Volunteer	Players have the opportunity to contribute to the community and help others (e.g. by picking up trash).

Step 4: Game play testing with children (this article)

The final step is the main focus of this paper namely to evaluate the SotS game, and the proposed challenge types (Table 2), to develop recommendations for future serious games for meaningful social interaction.

4. Secrets of the South

The game "Secrets of the South"[8,9] (SotS) is a pervasive location-based game designed to expose children to their neighbourhood, involve as many people in the game play as possible, through a smartphone, and do it in a fun way. It incentivizes players to search for solutions in the environment and engage with people, be these strangers or fellow players. Players have to perform outdoor activities (called challenges) that are designed for

[8] http://secretsofthesouth.tbm.tudelft.nl/, Secrets of the South, last visited on 29th Jun. 2020.
[9] https://github.com/xavierfonsecaphd/SecretsOfTheSouth, Secrets of the South source code, last visited on 29th Jun. 2020.

social interaction both in the real world (e.g. face-to-face communication, or physical contact), and in the digital world (e.g. exchanging messages, or leaving photos behind for others to see). Such challenges invite players to find and engage with people surrounding them, and are intentionally relevant for the neighbourhood (e.g. local heroes or points of interest).

Figure 1: In Secrets of the South, challenges allow players to encounter people or locations that otherwise stay unnoticed [28, 74].

Common functionalities of SotS are accessible through a main menu that shows the gameplay information to players (e.g. player avatar, leader board positions, and further options for configuration and customization of the game), the identity of the player as a QR code, and a QR code reader to interact with the physical environment and other players of the game. The game implements the types of activities from Table 2 as "functional types of challenges", and offers 6 types of challenges: Quiz, Multiplayer, Timed Task, Hunter, Open Quiz, and Voting. These invite players to play the game by completing tasks that require different forms of play, which vary from single to multiplayer, in their level of exertion, and functionality offered by the game (e.g. a timer, or validation of answers). Each of these types of challenges require distinct actions from players to be marked as completed (e.g. taking pictures, introducing text, scanning QR codes of hidden objects, vote, or form digital teams). Specifically for the Multiplayer challenges, players form digital teams by scanning each other's QR codes, and they can then do completely offline challenges (often involving exertion) that are then marked as solved by a game facilitator.

A key feature of the game is its ability to enable players to create their own challenges to play themselves and for other players to solve, thus sharing ownership. This is done through an online participatory system[8] where players can log in with their user account and create one of the 6 types of challenges. This enables players to include the places of their own neighbourhood they believe are most important to be visited, and share or expose players to fun facts or local history.

5. Research Design for Playtesting

Three playtest sessions were organized with the same primary school (and children) involved in the design of the challenges discussed above in Step 3 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 2 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 children 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 playtesting each child walks one route. The 14 challenges per route are described in detail in Appendix A.

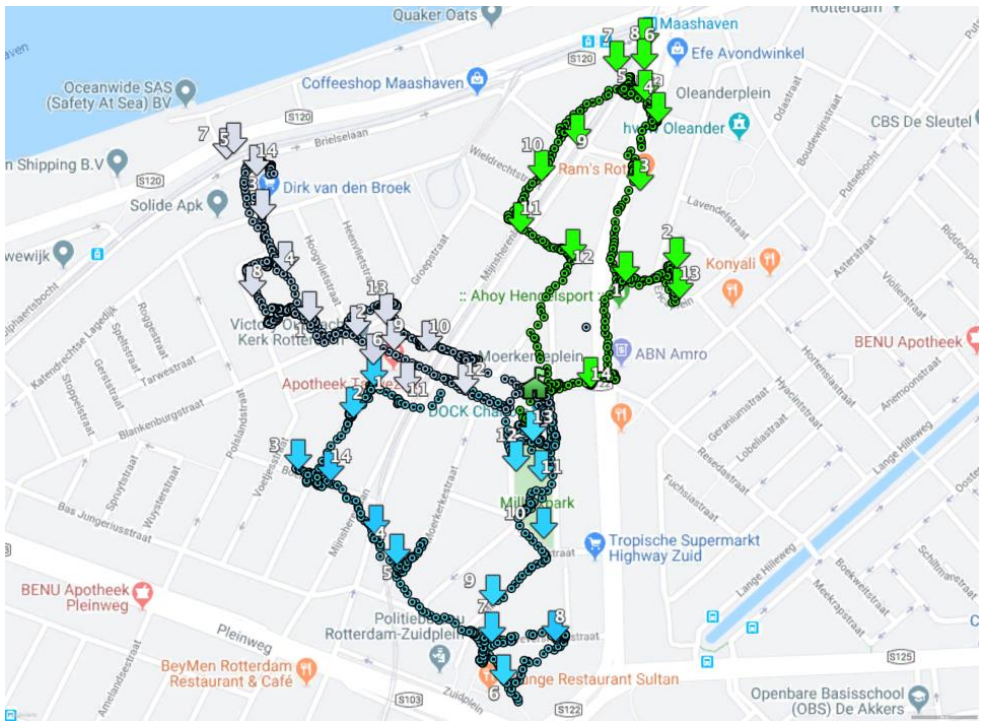

Figure 2: Route 1 (lime green), route 2 (light grey), and route 3 (light blue). Icon with the green house marks the school: the start and end point. Arrows mark the location of the 14 challenges per route, the dots the expected path.

5.1. Procedure

Three playtest sessions were organized, 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 playtesting session entailed:

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

In total 64 children between the ages of 10 and 11 participated in the playtesting 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 children 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 children's safety, to provide guidance when needed, and to collect data through observation. Each pair of children was handed identical mobile phones on which the game and the challenges were pre-installed[10].

Figure 3: Examples of the game play of SotS, by different groups of children: children interviewing strangers (top left), solving a challenge together (top right), competing against each other (bottom left), and playing together (bottom right).

[10] 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.

Figure 3 shows pictures of children 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 children per route, are depicted in Table 3.

Table 3: Division of children per play test session, groups and routes.

Session 1			**Session 2**			**Session 3**		
Group 7B (22 children)			**Group 8 (22 children)**			**Group 7A (20 children)**		
Groups	Route	Children	Groups	Route	Children	Groups	Route	Children
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

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.

5.2. 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). Children 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).

5.3. Perspective on social interaction

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 [1]. These exchanges are defined as "social processes" that contain several characteristics (e.g. purpose, repetition, structure, direction, and quality) [75].

The types of social interaction defined by literature vary in their types of exchanges (see Figure 4), and the exchanges this research focused on are the direct ones (i.e. between interlocutors):

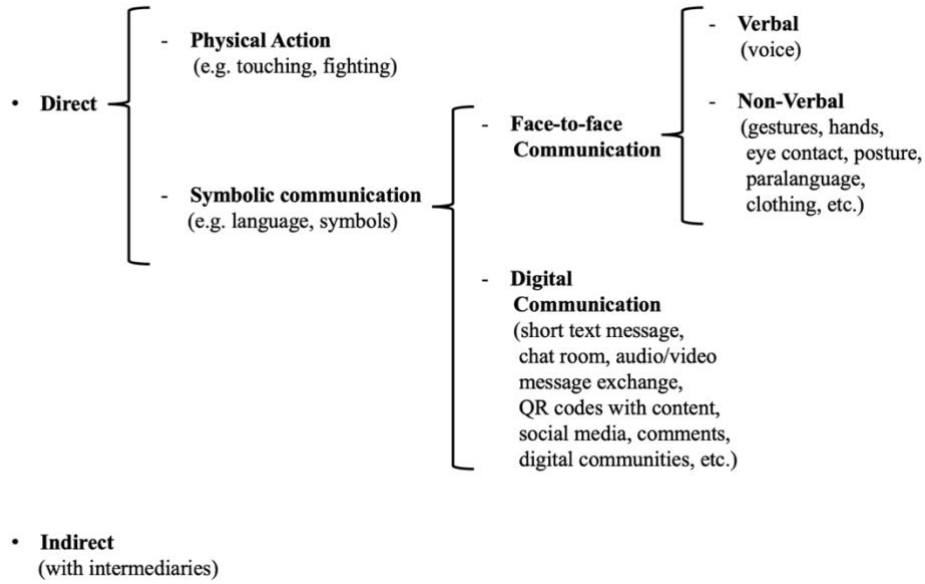

Figure 4: Types of Social Interaction.

5.4. 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 [76] to better understand the meaning of data in relation to the two research questions this article 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 children, 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 [77]. 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 [77]) to address the two research questions. Differences in coding were discussed à-posteriori with a third researcher, also involved in the game playtest sessions. The final coding framework contained codes to describe the general play

experience of children as well as specific experiences for each challenge type. The columns in Figure 5 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.

6. Results

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

6.1. Quantitative data

Table 4: Distribution of the interaction of players with each challenge, organized per type of challenge: challenge (**C.**) opened (**Op.**) and solved (**Sol.**) by players. The normalized average (**Avg.**) of opened and solved challenges is shown per type of challenge (in percentage).

	Artist			**Athlete**			**Detective**			**Explorer**			**Hunter**		
	C.	Op.	Sol.	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	1.3	8	5
	1.9	12	10	1.13	10	7	1.11	11	10	1.12	6	5	1.6	10	7
	2.3	12	12	2.9	9	9	2.1	11	11	2.2	10	0	2.11	8	7
	2.5	11	11	2.10	12	12	2.7	10	8	2.12	11	11	2.13	11	8
	3.1	10	10	3.10	8	7	3.4	7	5	3.6	10	10	3.2	10	0
	3.9	9	9	3.11	9	9	3.5	10	10	3.8	10	9	3.13	9	9
Sum (max 68)		**66**	**64**		**59**	**55**		**61**	**55**		**59**	**44**		**56**	**36**
Avg. (%)	**Op.:**	**≈ 97%**		**Op.:**	**≈ 87%**		**Op.:**	**≈ 89%**		**Op.:**	**≈ 88%**		**Op.:**	**≈ 83%**	
	Sol.:	**≈ 94%**		**Sol.:**	**≈ 81%**		**Sol.:**	**≈ 81%**		**Sol.:**	**≈ 66%**		**Sol.:**	**≈ 52%**	

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

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 4. C. refers 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.

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

$$x' = \frac{x - min\,(x)}{\max(x) - \min\,(x)} \quad (1)$$

Min-max normalization

$$AM = \frac{1}{n}\sum_{i=1}^{n} x'_i \times 100 \quad (2)$$

Aritmetic mean (%)

Table 4 shows the normalized average number of challenges opened by players, and challenges solved by players, per type of challenge, after the application of the equations 1 and 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 normalized 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.

6.2. 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*" (ch.3, s.1).
- [What did you like?] "*Helping people. For example, lifting their grocery bags.*" (ch.2, s.2).

Children 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.*" (ch.6, s.2).
- "*We could talk about things together. For example, the rap. [another child] 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.*" (ch.18, s.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 child-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 child] 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*." (child 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.*" (ch.19, s.1).

Children 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 children.

Type-specific Game Play

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 summarized in Figure 5:

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 children, 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, children 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. Children 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 parkours. 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. Children 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 children 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 children 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 children 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 children.

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 children. 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, children 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 children 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 children liked the challenges, with minimum collaboration and no competition, some in-group interaction, and individual play (no interaction). Children 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 children 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.

Table 5: Summarization of findings per type of challenge, with regard to the outcomes. Expectations that were met are marked in green.

	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 + non-verbal communication. • Collaboration and competition in-group.	• Physical performance with verbal + non-verbal communication. • Collaboration and competition in-group. • More competition than collaboration. • Children liked and had positive game play. Relatively easy to solve.
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 children 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 children. • 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 children. • 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 children. • 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 children. • Positive play experience.

6.3. Analysis of results

Figure 6 summarizes the quantitative data analysis on the percentage of the challenges that players opened, and, out of which, solved. Figure 5 summarizes the qualitative data analysis done. The columns in Figure 5 represent the results achieved with the final coding framework, and are used to answer the research questions

of this article: 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.

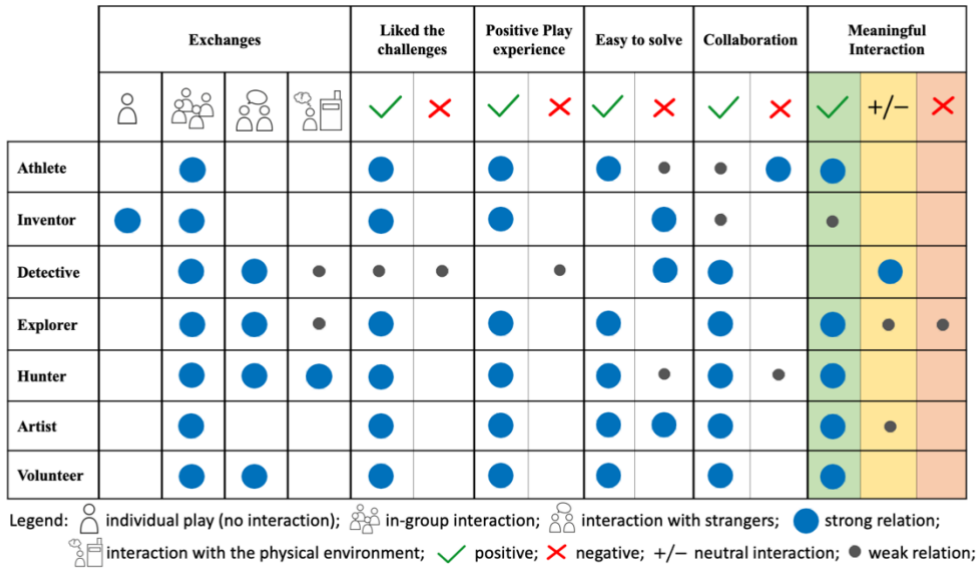

Figure 5: Summary of the game play per type of challenge: type of interaction fostered, how positive it was to players, and the dynamics and impact of the game play on players.

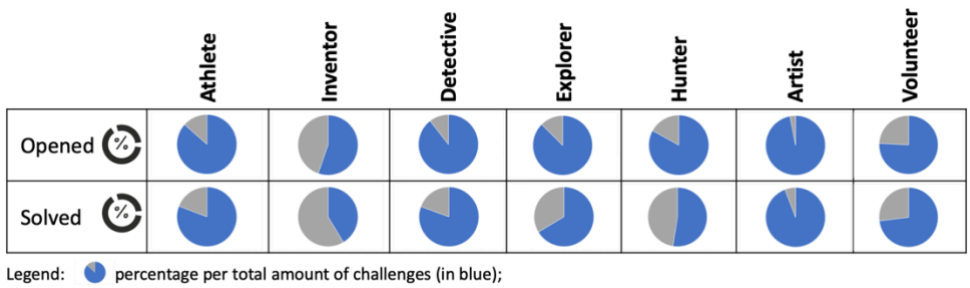

Figure 6: Engagement with challenge type.

The first column on the left of Figure 5 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 address how the game supported social interaction. These categories were assessed based 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 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 6, guide the answering of the research questions in the following subsections.

6.3.1. Social interaction that is meaningful

The first research question of this article 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 children holding smartphones, and in-group interaction where children worked together (not just in pairs). In 4 of the 7 types of challenges, children interacted intensively with strangers. In 3 of the 7 types of challenges, children interacted with the physical environment as well, that also lead to other types of interaction. In some types of challenges, children 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, children 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 a child’s own performance (rarely against other children). Children supported each other in difficult tasks, and either instigated other children to go talk to strangers, or the whole group was involved. Children 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. Children 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 children felt rejected (the neutral experiences described above in section 6.2), children 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 children to be arrogant.

The definition of *meaningfulness* in the context of social interaction defined above in section 1 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. Children interacted heavily in-group (which sometimes also included their teacher), and children had fun doing so for the most part. Children also interacted substantially with strangers in the challenges of the types Detective, Explorer, Hunter, and Volunteer, and, with the exception of the type Detective, children 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 children 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 children, and to explore the neighbourhood in different ways. Most challenge designs were experienced to be interesting and relevant for the children, 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.

6.3.2. The game creates opportunities for social interaction

The second question this article 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 child that did not like any challenge at all. Anecdotally, difficult challenges provided an opportunity for children 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 children 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: children 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 children, but they liked *Artist*, and did not like *Detective* as much. Children 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 children, particularly the younger ones (from classes 7A and 7B), and future games for this purpose and target group should assist children even further in navigating the map.

7. Discussion and conclusion

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 children in Rotterdam. This section summarizes the findings of this study as design recommendations, and relates these recommendations to the generic design guidelines described in Section 2.

7.1. Design recommendations

The recommendations, presented below in Table 6, 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 summarized

in Table 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 paper and in the literature.

Table 6: Design recommendations for serious games fostering meaningful social interaction.

	Recommendation	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).
5.	**Challenge content needs to be relevant for the children 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 children).
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 (Table 2).	
10.	**Within the group and with strangers:** Hunter and Explorer challenges are recommended the most. Detective challenges are recommended only if children relate to (or are fond of) the content of the challenge (Table 2).	
11.	**Primarily within the group:** challenges of type Athlete are recommended the most, followed by Hunter and Volunteer (Table 2).	

Laamarti et al's guidelines to "provide guidance to players" and to make "use of the display of the smartphone" [66], and to prevent players from feeling "lost" or confused as proposed by [78, 79], are related to the first two recommendations in Table 6. 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 6 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 [80] to "avoid negative consequences" as the result of the player's low performance aligns with recommendations 3 and 4 of Table 6: 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 [81]'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 6 is similar but for different reasons. Challenges where the children 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 children had to compete against, and collaborate with, one another, were very successful at maximizing social interaction. Even during the challenges were the children 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 6 relates to previous findings [82, 83], that advocate adjustment of the difficulty of the challenges to children to maximize their immersion in the game and improve overall gaming experience.

Existent research on game rewards and physical activity [84] 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" [66, 78]. Statements collected from children 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, children were strongly motivated by these, which makes us argue that physical exertion is a key factor for children's 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.

7.2. 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 children. 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 children use their own smartphone, one smartphone for the whole group, or having children interacting only with their friends). This study was made with children, with a narrow age range, and this limits the generalization 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 children 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 [85], and the levels of engagement in the game (GEQ) [86] 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.

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Ethical approval

This study was approved by the ethics committee of the Faculty of Technology, Policy, and Management of TU Delft. Approval was granted prior to all the sessions of the study, and GDPR-compliant consent forms for participation and data collection were handed out and signed by each participant’s legal guardians.

Conflict of interests

The authors declare that there is no potential conflicts of interest.

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Appendix A. Challenges played by the children

These are the challenges that stem from the co-design process followed previously to the case study reported in this article. Children ideated 49 activities they would like to do in their neighbourhood, and in specific locations, which had to be adapted to the game. The challenges that ended up being played by the children, per route, are detailed below, and cover all the different types of challenges (Athlete, Inventor, Detective, Explorer, Hunter, Artist, Volunteer [28]). All routes have 2 challenges of each type, so that children could play all types of challenges regardless of their route.

Route 1:

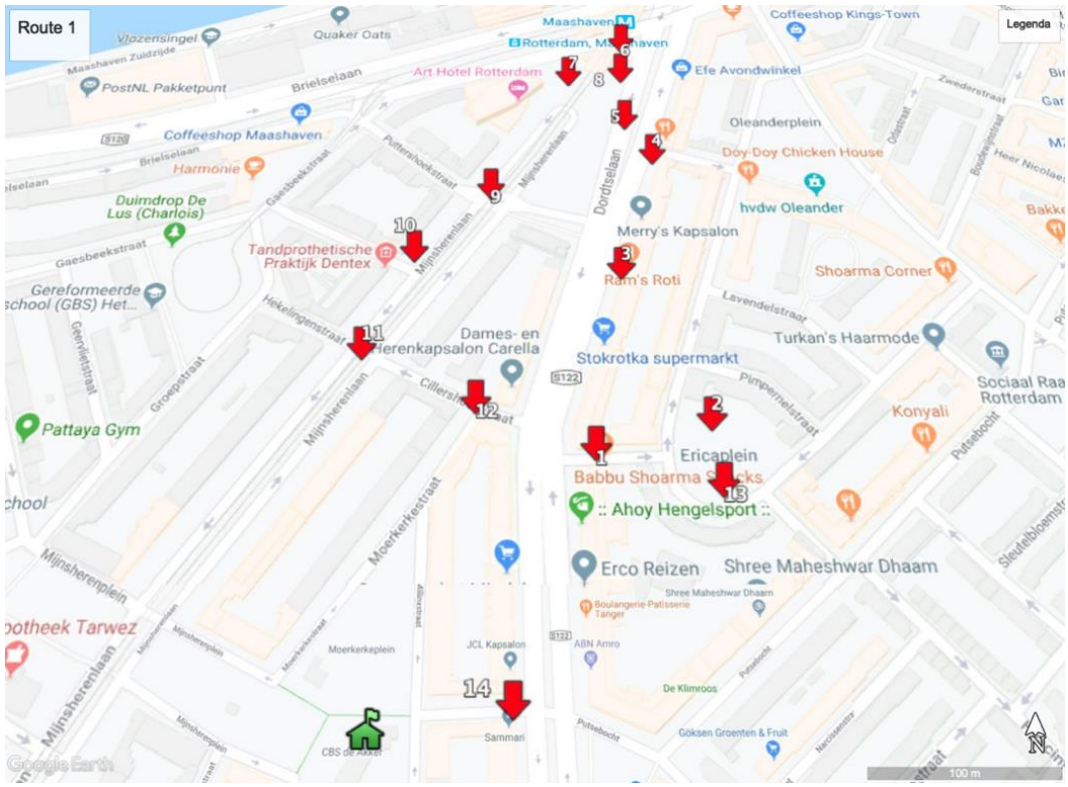

Figure 7: The locations of the 14 challenges placed in Route 1. The icon greenhouse demarks the school (starting and ending point), and the red arrows regard the positions of the challenges

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

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. (Children 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

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
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

Route 2:

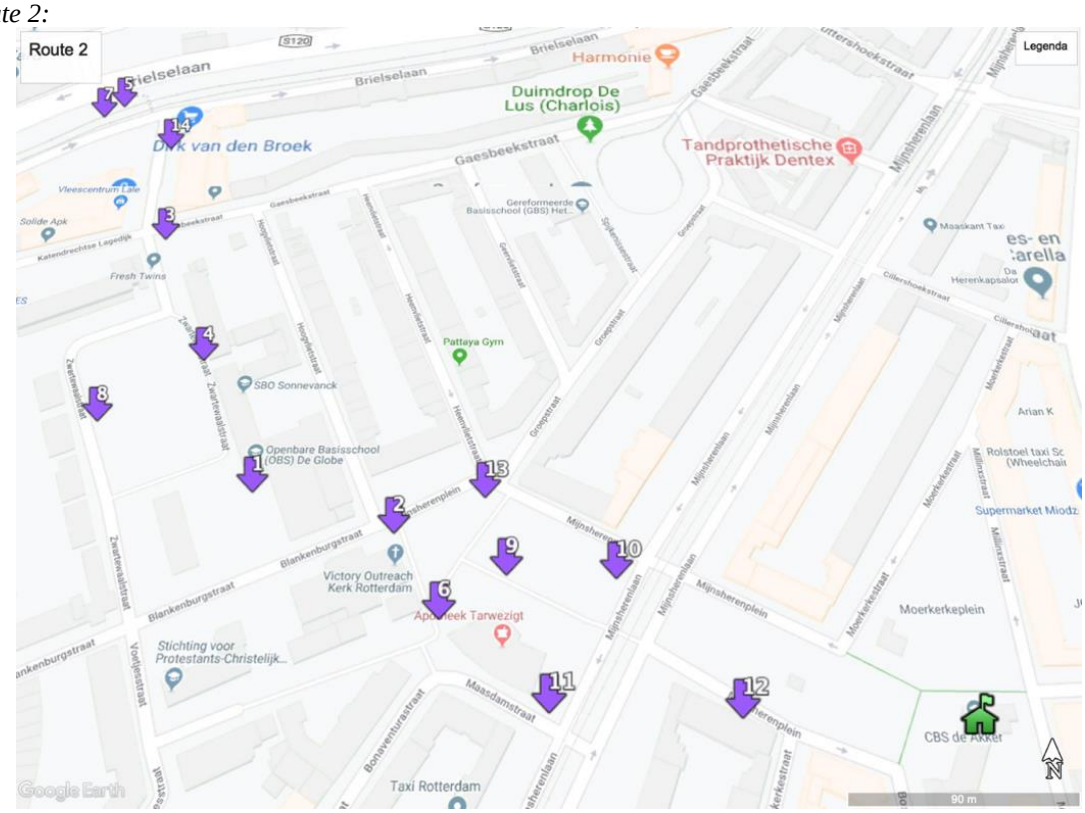

Figure 8: The locations of the 14 challenges placed in Route 2. The icon greenhouse demarks the school (starting and ending point), and the purple arrows regard the positions of the challenges.

Challenge 1:	**School's out!**
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
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
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 someone's 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

Route 3:

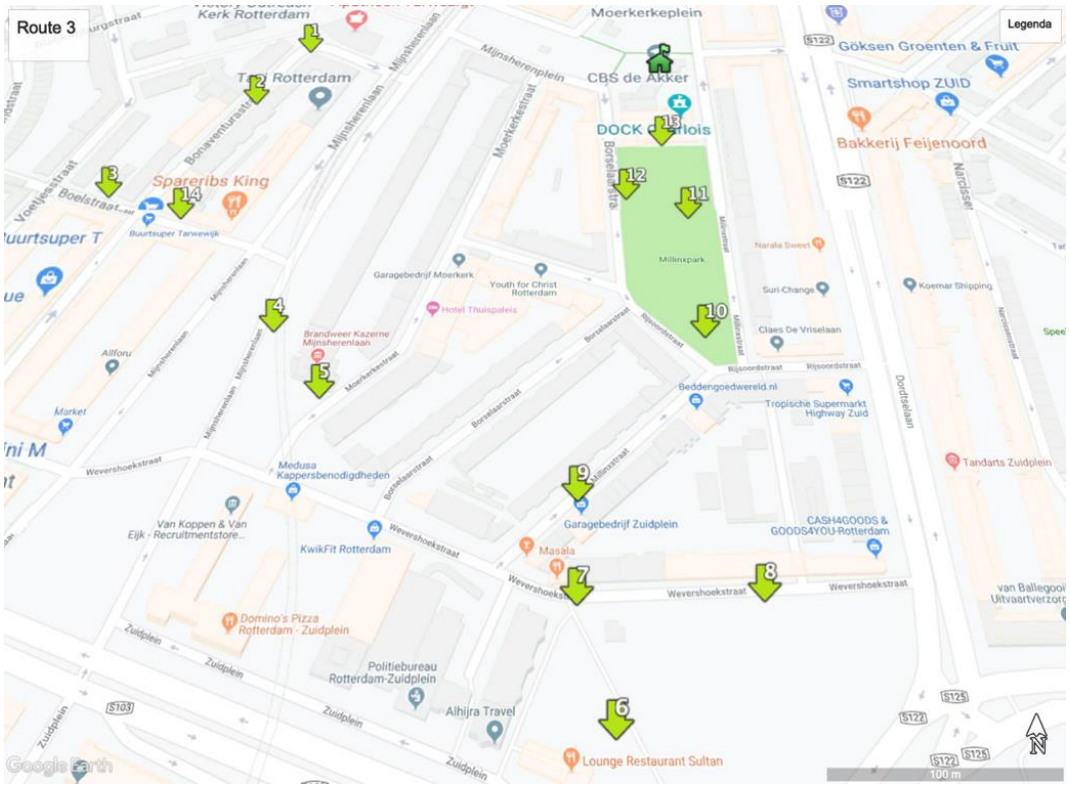

Figure 9: The locations of the 14 challenges placed in Route 3. The icon greenhouse demarks the school (starting and ending point), and the lime green arrows regard the positions of the challenges

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

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? (Children 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

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 parkours. How fast can you do the parkours?
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
Task	The community centre is a central place for youngsters, children 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