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Secrets of the South: A Location-based Game for the Development of 21st Century Social Skills and Promotion of Social Interaction

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Abstract. Location-based games (LBGs) successfully promote playful experiences engaging millions of players throughout the world. The potential of embedding such location-based experiences in educational practice has been recognised but not yet fully embraced. LBGs and educational location-based applications have been used to enhance critical thinking, but not for the acquisition and development of 21st century skills: key competences required to understand, live and thrive in the local communities of today. This paper introduces the LBG 'Secrets of the South', designed to orchestrate social interaction in public space, and foster communication, collaboration, IT literacy, and social/cultural skills through 1) interaction-based social encounters with both friends and unknown members of the community, and 2) in-situ learning about the history and social context of the neighbourhood. A 4-step general procedure is proposed for the creation of LBGs designed to foster 21st century skills.

Keywords: Location-based game, Social interaction, 21st century skills development.

1 Introduction

Location-based games (LBGs) are a relatively new type of game (since early 2000's) that enable innovative forms of play when compared to traditional games [1]. Their ability to blend the fictitious and surrounding real environment of players, together with their very contradictory gameplay between the crossroads of "fun" and "serious", render them a very promising means to approach existing societal challenges in a unique way [2]. LBGs expose players to the real world and invite them to actively engage and interact with both their surroundings [3]. Due to these affordances, LBGs have been

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explored for the betterment of society [4-12], such as fostering meaningful social interaction in public space [13].

Meaningful social interaction is argued to be one of the key requirements for social cohesion and social resilience. Meaningful social interaction has shown to be essential to break down stereotypes and prejudice, increase people's ability to act, and address conflict [14]. Several LBG-based initiatives have been successful at promoting community-wide playful behaviour that brings communities together to this purpose [15].

Such interaction requires 21st century skills [16, 17]: the social and cultural skills needed for citizens to understand and grow in today's ever changing societies [18, 19]. These skills include the ability to work with others in multi-cultural environments, to build and maintain a social network, and to communicate and collaborate with (both known and unknown) others [16, 20]. The importance of critical thinking is well recognised: 70% of the games developed for educational purposes focus on this skill [21]. The potential of educational location-based games and applications with high real-life relevance for other 21st century skills, however, has yet to be successfully embraced in formal/informal educational settings [22].

This paper presents an LBG designed to foster social interaction in public space and played by children, adolescents and adults in their own neighbourhood, and deployed to this purpose. This LBG supports the development of communication, collaboration, IT literacy, and other social/cultural skills through 1) **interaction-based social encounters** with both friends and unknown members of the community, and 2) **in-situ learning** about the history and social context of their local neighbourhood. This paper also proposes a general procedure to create similar LBGs in the future, a procedure where future players are invited to be at the centre of the development process and asked to inform on the gameplay most meaningful to them.

The next section presents the background on location-based games developed for social interaction and the development of the 21st century skills. The following sections present the research context, methodology, game design, and a discussion on the implications of the design for learning 21st century skills. The last section presents a conclusion and discusses limitations of the research and directions for future work. A detailed discussion of the design choices behind the proposed game design based on the requirements presented in the research context section is included in the appendix.

2 Background

LBGs are designed for/require players to interact both with their physical surroundings, as well as socially with people within and outside the game world. They are known to expand the fictitious boundaries of play that traditional games offer with an ubiquitous outdoor play experience in an outdoor location (with GPS coverage) with its specific context (dependent on the availability of network service) [3]. Such games can provide powerful forms of entertainment, exposing players to the real world and inviting them to actively engage and interact with their surroundings [23]. Pokémon Go is an example of an LBG [4] that has become so successful that cities have explored its use for purposes such as boosting civic engagement in local communities, involving up

to thousands of people [15], and increasing meaningful social interaction in public space (linked in turn to the strengthening of the social fabric of local communities).

2.1 LBG Initiatives for Social Interaction

Examples of commercial LBGs that trigger interaction include Pokémon Go [24], Ingress [9], BotFighters [6], and Geocaching [25], all of which motivate players to move around a physical location, collect items, interact with real objects, and play individually or in a team of players [26]. LBGs designed for research purposes such as Insectopia [10], Mythical: The Mobile Awakening [27], Day of the Figurines [5], and City-Conqueror [12] are based on similar gameplay, and have been explicitly designed to explore the impact of various design choices and game features [28]. Many of these games have successfully fostered social interaction although it is often unclear why and how [26, 29], as the aims often differ. Most LBGs, both commercial and academic, are designed and developed without the involvement of users in early stages of game development for which requirements elicitation is an in-house process, often involving users in the testing phase. Recent research indicates the need for a better understanding on how to best design LBGs for meaningful social interaction, and the need to involve users and their preferences in early-stages of game design [26, 29-32].

2.2 Educational Game-based Applications for 21st Century Skills Development

During the 20th century traditional educational systems focused on teaching specific knowledge that was key to society's economies [33]. Current insights support more competence-based education in which skills and insights needed in today's society are key. Although studies differ in the skills distinguished, a number of skills are almost always named: communication, collaboration, ICT literacy, and social/cultural skills [34, 35].

Serious games for learning provide an environment specifically designed to enhance the acquisition and development of both knowledge and skills that can be tailored to guarantee a sense of achievement when a task is completed, and evidence shows that these encourage meta-skills such as critical thinking, argumentation, collaboration, and decision making [36-38]. As stated above reviews show that 70% of the studies done on the promotion of the 21st century skills are directed towards critical thinking skills, and only one study was found with the focus on communication as a learning outcome [21]. The scarce research on games for the development of social and cultural skills is limited to the usage of virtual worlds, where interpersonal competences such as communication, social and cultural skills are promoted through virtual interaction and avatars [34, 39-43].

This issue is also not currently being addressed in the new trend seen in education: educational location-based applications (ELAs) [22, 44]. ELAs are either applications, serious location-based games, or commercial LBGs that leverage on the technological abilities of smartphones to achieve learning outcomes, and have mostly been explored

for environmental education [44-50]. Researchers have been studying the learning effect of ELAs and the justification [51, 52], but they have failed to address 1) the balance between complex and simple game designs to fully explore the affordances of LBGs for learning outcomes all the while lowering technological barriers felt by teachers and students in the adoption of such tools; and 2) the usage of ELAs specifically for the development of 21st century skills [22].

On the former point, researchers swing between relatively simple and complex game designs: more complex designs rely on virtual environments to maximize immersion and motivation (and report issues such as higher cognitive load) [45], and relatively simple designs focus more on engagement levels, but are not technologically ambitious and thus fail to fully explore the possibilities ELAs afford [34, 53]. On the later point, researchers have focussed on both specific game characteristics (such as augmented reality and storytelling) and gameplay outcomes (e.g. immersion, engagement) and not on acquisition of 21st century skills [44, 54, 55]. This means that location-based games and applications are not focusing on the 21st century skills, are either too complex to be adopted or too simple to provide substantial added value, and thus fall short on the positive impact they can have on societies.

This paper argues that LBGs for acquisition and development of 21st century skills require a balanced game design, one that is capable of exploring the affordances of LBGs for effective learning outcomes, and with a low technical barrier to be set and maintained by teachers and students.

3 Research Context

The research on which this paper reports has been performed in the context of a larger programme on the design of meaningful social interaction in public space through LBGs in the Hague and in Rotterdam in the Netherlands. This programme included understanding the need to positively impact social cohesion and social resilience in local communities. To such end, this research contacted the municipality, the Police, a cultural Thinktank, and three schools (two secondary, one basic) in Rotterdam, NL, and a community centre in The Hague, NL, to better understand the social environment and the preferences and needs of local communities. On the one hand, the non-educational actors involved (municipality, police, cultural Thinktank, and community centre) argued that a positive approach (such as games) could be beneficial to some of the local issues (e.g. related to safety, or lack of neighbourhood engagement). On the other hand, schools in Rotterdam were particularly engaged with projects that could be adapted to their existent curricula and that could help promote 21st century skills such as IT literacy and contextual-based learning. They argue that local communities surrounding their schools are rich in historical legacy, and that enabling a way for their pupils to be exposed to it in a fun and engaging way would promote their education.

In such exploration, this research learned that social interaction is a key requirement for the promotion of social cohesion [56]. Such social interaction mandates 21st century social and cultural skills. From this requirement (the central requirement in **Fig. 1**), followed the exploration of LBGs with players engaging 1) within their own neigh-

bourhood, 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 **Fig. 1**).

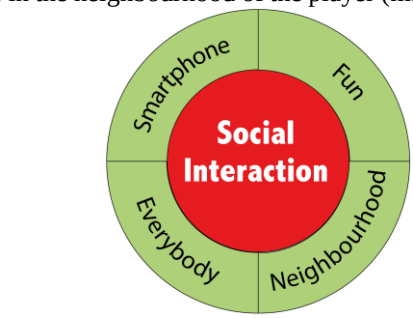


Fig. 1. Requirement for social cohesion and initial constraints

3.1 Research Methodology

The game design presented in this paper is a product of an iterative design approach [57]. Research in game design argues that an interactive system requires an iterative design approach with iterations of requirements and (partial) design artefacts/prototypes [58-60]. The specific stages of an iterative approach named in the literature vary [61-63], 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 **Fig. 2** (with more detail in the Appendix).

[1] https://www.enginess.io/insights/what-is-iterative-design, What is iterative design?, last visited on 19th Aug. 2020.
[2] https://www.bipsync.com/blog/iterativeproductdesign/, Iterative product design, last visited on 19th Aug. 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 19th Aug. 2020.

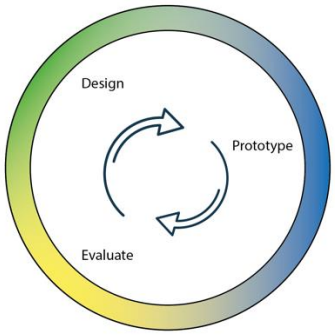


Fig. 2. Iterative design process followed in the process of game design, development and validation with (potential) players.

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 in educational settings (schools of Rotterdams Vakcollege de Hef, and Scheepvaart en Transport College, Rotterdam, NL) [29].
2. Research on requirements for a systems' architecture for LBGs for social interaction [64].
3. Design: conceptualization of initial game design.
4. Development of the first game prototype.
5. Evaluation of first prototype in case study 2 with adults in an informal setting. Feedback of participants was collected to inform further design and development [31].
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.
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 in an informal setting [30].
9. Co-design of gaming activities as case study 4 with children in an educational setting (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.
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 in an educational setting (same of step 9) [13].

The products of these stages, organised around the adopted iterative design methodology, are 1) insights on the potential of LBGs for acquisition of 21st century skills, 2) a 4-step general procedure to create LBGs for meaningful social interaction in public space, where 21st century skills are acquired/developed (section 4), and 3) the game design of a fully open-source LBG prototype for the identified purpose, 'Secrets of the South' (SotS) (section 5). Further details on the intermediary case studies can be found in [13, 29-31], and lessons learned are summarized next.

4 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 5), which produced key information concerning the preferences and needs of both adolescents and adults for the type of interaction and social exposure they want to experience. These lessons learned are detailed below, and treated as requirements for the LBG presented in this article:

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 runtime dynamics of play desired by players (organized in the upper left quadrant in **Fig. 3**) [26, 29].

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 [30, 31] (**Volunteer**) - upper right quadrant in **Fig. 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 **Fig. 3**).

Step 4 - For social interaction in public space via LBGs, essential architectural components are [64]: **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/participation, and manage the game (see bottom left quadrant in **Fig. 3**).

Fig. 3 summarizes 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 (c.q. learners) prefer, want, and desire to play in their own neighbourhood. This concept has been developed and validated in an LBG [13], and described in the following section.

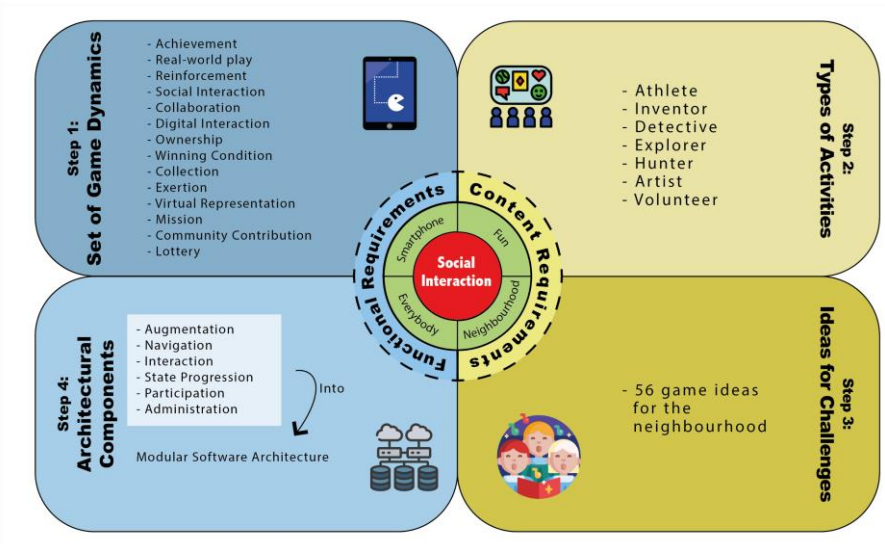
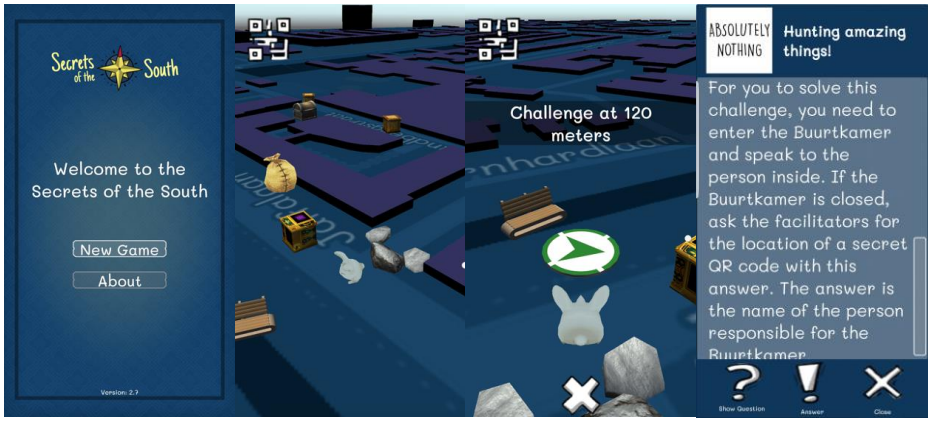


Fig. 3. Information for the creation of location-based games for social interaction tailored to the public space surrounding players: user-centred requirements, and key architectural components.

5 Game Design: Secrets of the South

'Secrets of the South'[4,5] is a location-based game that invites players to discover and solve challenges (outdoor activities) designed for social interaction. Challenges are linked to specific real locations, and require players to walk to these locations to find them. These challenges require players to play together with their friends in collaboration and competition, involve unknown people nearby in the gameplay, and explore the outdoor public places around them while looking for clues to solve the challenges (**Fig. 4**).

SotS is designed to invite players both in the real world (e.g. with physical contact and/or face-to-face communication) and the virtual (e.g. through the discovery of QR-enhanced real objects with messages left by other players). 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 that are not often noticed in the neighbourhood (e.g. local heroes, or the most important landmark in the country). Each player has an identity QR code that can be scanned for points and for counting real-world interactions/friendships. Progress in the game is measured through the friendship points players have, and the number of challenges solved. The SotS augments players' awareness of their surroundings through the digital 3D representation of the player (a genderless rabbit), the location where players are on the map (e.g. the street, a park), and the surrounding infrastructure (e.g. apartments) - **Fig. 4**.b and c. Throughout gameplay, players can select nearby challenges and tap to find their location, revealing an animated 3D compass that points to the location to which players should walk. The challenges that players need to find are also represented 3D on a map, and once players are close enough (50 metres within range), the information of the challenge and the to-do task can be revealed (**Fig. 4**.d).



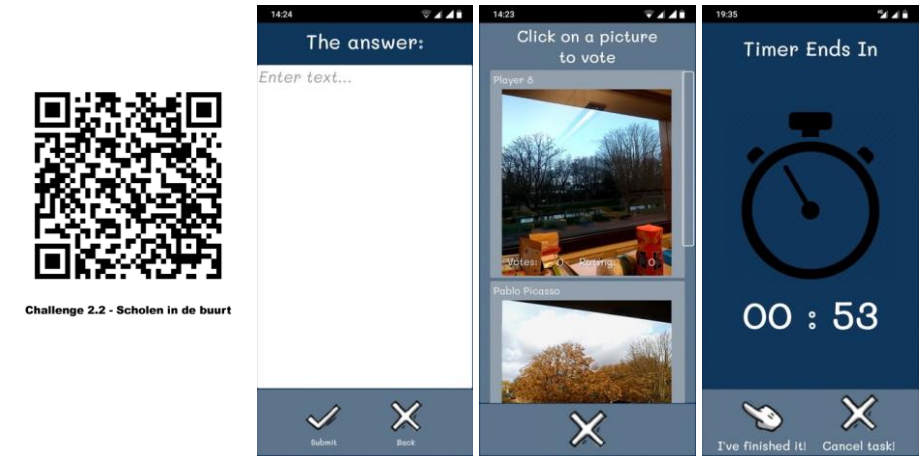
a) b) c) d)

[4] http://secretsofthesouth.tbm.tudelft.nl/, Secrets of the South, last visited on 19th Aug. 2020.
[5] https://github.com/xavierfonsecaphd/SecretsOfTheSouth, Secrets of the South source code, last visited on 19th Aug. 2020.

Fig. 4. In Secrets of the South, challenges allow players to encounter people or locations that otherwise stay unnoticed [30].

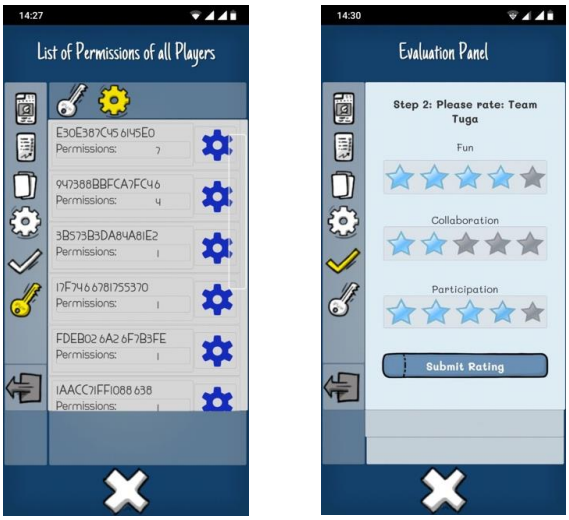
5.1 Functional Challenge Types

The different activities proposed by the game require different functionalities from the game. 6 functionalities are provided: Quiz, Multiplayer, Timed Task, Hunter, Open Quiz, and Voting. A Quiz presents a closed question (e.g. "How many guards …") with a closed answer (e.g. "3"). A Multiplayer challenge facilitates team-based offline activities (e.g. tick tack toe), and requires an external facilitator to evaluate correctness. A Timed challenge specifies a specific time frame (e.g. "Find 5 non-Dutch people within 3 minutes") - **Fig. 5**.d. A Hunter challenge presents closed quests (similar to Quiz), with clues on how to find the person/object sought, requiring a specific QR code to be scanned as proof of success, supported by additional information (text or images) on the neighbourhood (**Fig. 5**.a). An Open Quiz challenge presents players with open questions (e.g. "How do you feel about …"), to be explored and answered (and are not further evaluated) (**Fig. 5**.b). Finally, a Voting challenge invites players to take a picture of something in the neighbourhood as an answer to a quest and upload it to the game (with no further evaluation) after which they can vote for solutions given by other players, thus enabling digital interaction **Fig. 5**.c.



a) b) c) d)

Fig. 5. 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.



a) b)

Fig. 6. Evaluation in Multiplayer challenges. a) Permissions of all players. b) Evaluation of a team's performance.

Most types of challenges are marked as solved by the game, right after the player answers a question, finds a QR code, or uploads an image, and points assigned: 5 points for incorrect or almost correct answers, 10 points otherwise. Multiplayer challenges are an exception as they require players to perform activities that cannot be automatically validated by the game. To have access to this type of challenge, players must form a team first by scanning each other's QR IDs. Registered game facilitators with evaluator rights need to be located in the premises of such Multiplayer challenges (**Fig. 6**.b), to rate a team's performance and mark the challenge as solved. SotS distinguishes 3 types of player accounts: player, evaluator, and administrator. Dynamic change of roles during gameplay is supported (**Fig. 6**.a).

5.2 Participatory System

Fostering player participation during the gameplay is known to fuel longer-term gameplay, as it tailors the game around the fun and playful behaviour players like most [65]. As gameplay in SotS is designed for social interaction longer-term gameplay is a goal. SotS has been designed to support players in creating their own challenges. These challenges are necessarily linked to specific locations, specifying activities appropriate to the context of the neighbourhood and the game mission.

Central to SotS is an online information system that contains games and their challenges. This system is managed by an administrator, whom can create new accounts for players (described here[5]). Players in turn, or the administrator, can then log into the system and access the list of challenges available throughout the world (**Fig. 7**).

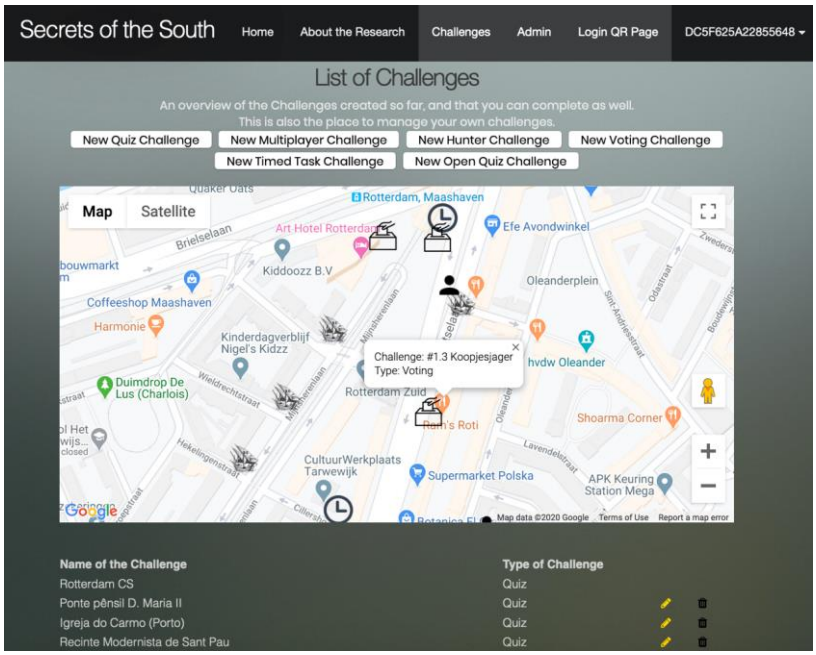


Fig. 7. Participatory system, and the visual exploration of the location of challenges.

A player can create a challenge of one of the 6 types described above specifying the specific information required (name, description, location, picture of the challenge to appear on the mobile game, the task required, and possible answer – depending on the type of challenge involved). Upon completion the administrator (automatically) receives a request to verify the correctness and ethics of the challenge (e.g. foul language should be avoided), and whether it can be made available to others (or not). This is a security measure that is of specific importance for educational environments (e.g. younger adolescents). The system presents a map on which players can click to locate challenges, their type/name, and edit their own challenges. A reserved area is also available to administrators for system management.

6 Discussion: Secrets of the South and the 21st Century Skills

SotS game has been designed to support social interaction in socially challenged neighbourhoods in Rotterdam and the Hague, tested and evaluated within educational settings mandating development of 21st century skills [34, 35, 66-68], specifically: *communication*, *collaboration*, *IT literacy*, and *social/cultural skills*.

Communication. This skill plays a central role in many forms of interaction. Verbal communication is a direct way of interacting: the exchange of language and symbols

(symbolic communication) mediates face-to-face and digital interactions [69-71]. Interacting socially stimulates effective communication, because it puts communication into practice [66]. SotS promotes both digital and face-to-face communication. Digital communication is needed when players scan each other's QR codes to count "friendships" made and to form teams, when players vote for each other's pictures, and when QR codes are placed in an environment for players to leave texts and images for other players to find. Face-to-face encounters are promoted in all of the gaming activities designed for players to play together (e.g. multiplayer challenges) and work together.

Collaboration. SotS offers functionality that promotes collaboration (e.g. team formation) and competition leading to in-group collaboration (e.g. solving the most challenges as a team, and be seen in the team leader board). It mediates team formation, invites players to take on different roles in the team, and enables joint coordination and performance [66, 72]. Challenges designed to promote collaboration designed by school participants included jointly coming up with a rap song, coordinating athletic parkour performance with others, and brainstorming about new names for a street.

IT Literacy. The game layout of SotS exposes players to 3 possible languages (English, Dutch, and Portuguese), and provides an authoring tool for participants to add new game content (challenges) in any of these (or other) languages. ICT literacy required for the visualization, understanding and manipulation of game elements [67, 73, 74] is also implemented in SotS, as it requires the understanding of how to navigate a digital map and 3D compass to reach the challenges, which was a challenge for younger players [13]. The SotS mobile application also requires the navigability throughout the menus of the game for everything (e.g. avatar exchange, QR code scanning, and leader board viewing), which players have to learn.

Social/cultural skills. SotS purposefully facilitates the development of social and cultural skills throughout the game. On the one hand, it offers in-situ learning about the history and social context of local communities, by promoting a gameplay experience that exposes players to the social and cultural environment of the neighbourhood. Challenges invite the discovery of local history and facts that may not be common knowledge to residents, while exposing players to the social context of the community. This in turn makes players aware of who is living in the neighbourhood, and exposes them to any diversity (e.g. ethnicity, languages spoken, and social behaviour). On the other hand, social and cultural skills are acquired and developed in the SotS through direct interactions and social encounters. These occur with both friends and unknown people, as the SotS is developed to involve others in the gameplay.

7 Conclusion

This paper explores the potential of an LBG to foster 21st century skills and its design, and proposes a 4-step general procedure with which future similar LBGs can be created.

Based on the interaction preferences, needs and desires of children, adolescents and adults, the game design fosters social interaction through gaming activities that mandate development of 21st century skills (specifically, communication, collaboration, IT literacy, and social/cultural skills). SotS is a product of an iterative design approach where player/learner requirements were repeatedly elicited, and where all initial requirements, constraints, and player/learner requirements were taken into account to produce a game capable of facilitating meaningful social interaction for which 21st century skills were vital. 3 case studies were done to validate the triggered social interaction: the 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. They followed the proposed 4-step general procedure, where future players are put in the centre of the game development and asked: 1) the set of game dynamics that appeal to them most; 2) the types of activities that the aimed LBG should ideally offer them; and 3) specific game ideas to introduce as game content on their own neighbourhood. Parallel to these steps was the identification of the technical requirements (such as architectural components) that this type of games mandate.

LBGs such as SotS can be used to develop 21st century social skills needed for social interaction in both formal and informal educational settings. Players of the SotS are exposed to a gameplay that invites skills such as communication and collaboration to solve challenges, skills such as IT literacy to navigate through the bend of real and fictitious game LBGs offer, and social skills required to involve others in the gameplay and be physically exposed to the neighbourhood. The SotS can be used by players alone, or by players and teachers for an integration in existent curricula aiming for contextual learning and 21st century skills development. The proposed LBG requires an initial setup, after which it can be operated by teachers and non-technical professionals with a low-maintenance effort.

With this being said, SotS requires further evaluation to more strongly measure its impact in different target groups, and within the same target groups in other social contexts. It was also developed within the greater aim to promote positive social impact and neighbourhood pride. Informal educational settings can benefit from SotS, as the game promotes the completion of co-located ludic activities, which in themselves may promote higher engagement levels when compared to traditional educational settings. Further studies should assess 1) how engagement changes in learning outcomes related to the history and social context of local communities with and without the SotS, and across formal and informal educational settings; 2) how the SotS can be integrated with broader curricula for the maximization of learning outcomes; and 3) the extent to which the SotS develops these and other 21st century skills can be measured.

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8 Supplement: Discussion of Design Choices

The design choices taken throughout the implementation of the game are influenced by the findings of the studies reported in the methodology section, 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) 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.

8.1 Initial Requirements

As shown in **Fig. 3**, the initial requirement is the development of a game that can trigger social interaction, and do so while exposing people to the neighbourhood, mandating the development of 21st century social skills. This lead to the selection of the game genre location-based games: 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 programme set 4 constraints based on the lessons learned from [26, 29-31]. 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. These studies 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.

8.2 Implementation of Functional Types of Challenges

Several of the lessons learned from [26, 29-31] influenced the choices of which functionality the game SotS should have. Knowing the types of activities that participants want to play (from the framework of activity 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 article 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 potential players 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. The Quiz challenge is materialized from the *Detective* type of activity, and the ideas fitting this type. Participants 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 **Fig. 8**). 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.

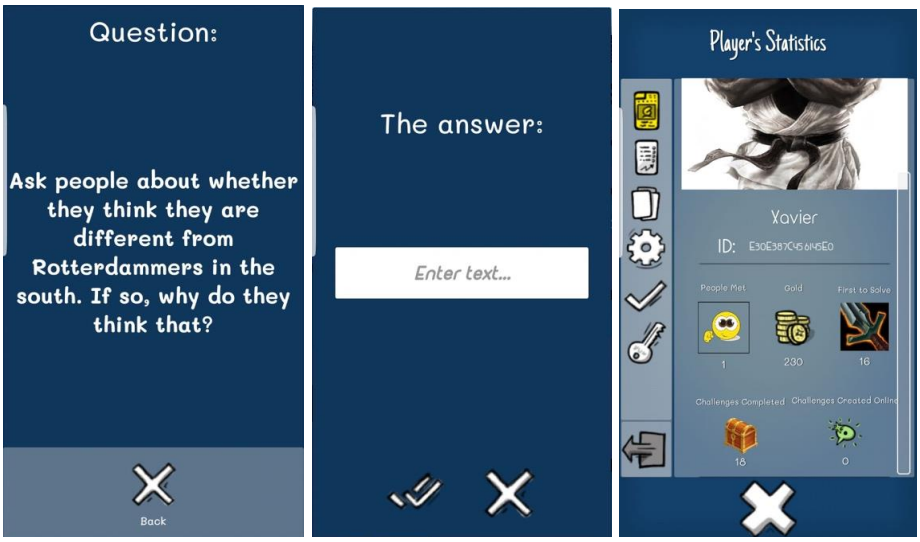


Fig. 8. Design choices with the Quiz challenge (Question – left, Answer – middle, point attribution - right).

Multiplayer Challenges: Participants 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 parkours, 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.

As such, the first 2 design choices for this challenge are the request to have players perform a task (instead of giving an answer - **Fig. 9**.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 participants 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).

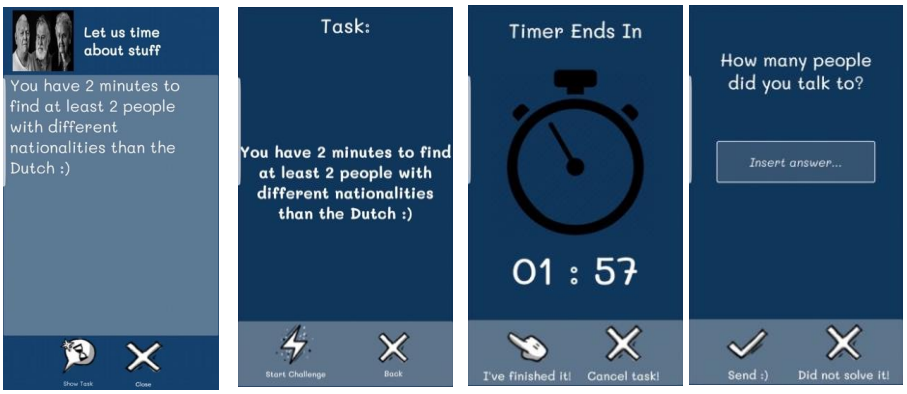
a) b) c) d)

Fig. 9. 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).

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 players 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. Some of the challenges participants provided that are specific to the type *Athlete* require tracking 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 count-down 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.



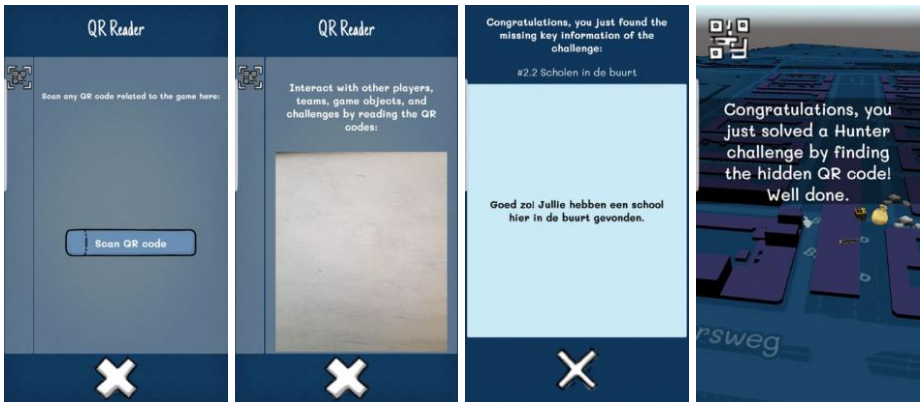
a) b) c) d)

Fig. 10. 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 number of points (e.g. 10 points), that are then added the number of things the player did/collected in addition. 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.

Hunter Challenges. The type of activities *Hunter* from the topology translated to new functionality in a straightforward way, leading to this type of challenge. The ideas participants 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.



a) b) c) d)

Fig. 11. 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 **Fig. 8**). 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. The implemented flow of solving this type of challenge (**Fig. 11**) is 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.

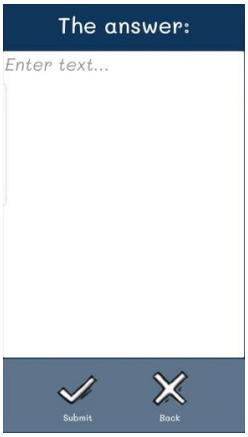


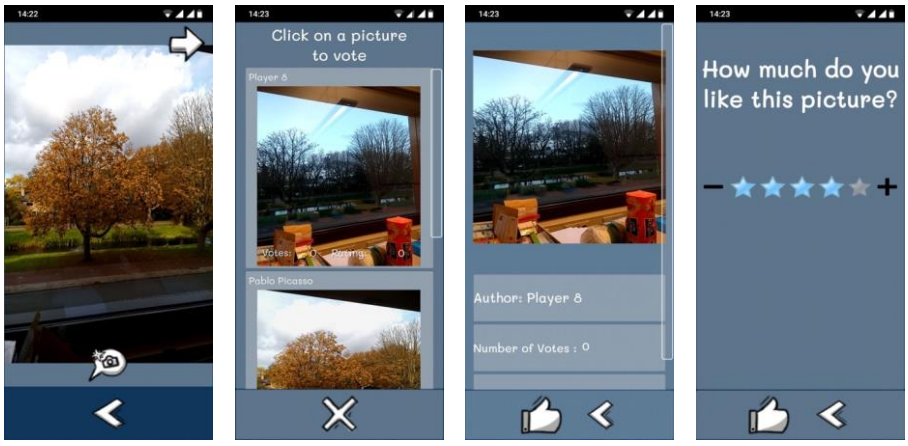
Fig. 12. Design choices with the Open Quiz challenges.

Open Quiz Challenges. Several ideas of activities from the participants 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, participants 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). 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 (**Fig. 12**), 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 participants 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.



a) b) c) d)

Fig. 13. Design choices with the Voting challenges (a – functionality of taking a picture, b – solutions given by all the players to this challenge, c – the details and votes of one picture, and d – voting for a picture).

8.3 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 for game designers and developers. It is a list that involves substantial implementation and careful planning during the design of a game, that, depending on the time and effort involved, might not be possible to be implemented entirely or coherently within one game idea. As a game developed throughout the better part of 2 years, SotS contains design choices that implement all of the 14 dynamics, and these are explained below (sorted by order of importance, first being the most important to participants – see [26]):

- ***Achievement***: 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. In addition most types of challenges really stress the physical activity component, without which players cannot find the answers or complete challenges.

- ***Reinforcement***: SotS aims at fostering play and engagement by implementing the attribution of badges, points and gold, associated with 1) 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 the player's icon (badge) based on how high their numbers are: for e.g., the number of people met (**Fig. 8**, 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 currently provided 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 perfor-

mances. Secondly, 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 perform activities involving physical effort in *Multiplayer* challenges, that 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***: SotS implements an avatar, that 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 enables 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, mandating the development of 21st century social skills.
- ***Community Contribution***: The challenge designs provided by SotS, 1) based on what users want, and 2) tailored for social interaction in public space, include passers-by, but also 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 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).

8.4 Separation of Content from Functionality, and Implementation of the architecture with its key components

One of the design choices of SotS was the implementation of an online content management system (CMS), which, from the lessons learned from [64] (the essential modules of participation and administration), resulted in the CMS being named SotS participatory system (**Fig. 7**). 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 [31] and [30]), 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., allows for the quick introduction of the several game ideas participants had, to test them in their own game play. This led to the implementation of an online information system in three stages: during the first stage of development, challenges were put into the system and synchronised with the mobile game application; during second stage, players were able to introduce these challenges themselves; during the third stage, an administrator double checked the content proposed by players on appropriateness (e.g. foul language, or unsafe locations), and was given the option to 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 is in line with the essential architectural module of participation from [64], providing players a contributing role in the game that contributes to a recurrent game play over time. The third stage is in line with the essential architectural module of administration from [64], to enable centralized coordination and upkeeping of the entire game, the content of the game, the players, and their statistics, all the while proposing challenges as well.

The implementation of the architecture and the key components that an LBG for social interaction should have are also available in [64].