Evaluation of the Concept of a Smart City Gamification from a User Centered Design Perspective

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Abstract. Galvanize the citizen to be engaged with a smart city project projects are not an easy task, normally they feel that their voice cannot make the difference and leaves the project. Gamification can change this, by engaging the citizen with challenges and rewards, they will be involved creating "critical mass" to influence the makers and change the city. In this context, this paper presents the evaluation of a gamification strategy concept for the Smart City Sense Project implemented in a mobile application. The evaluation was done by a questionnaire with 41 questions, filled by a group of 23 citizens that was already involves in city civic activities related with security. In general, this special population has a positive reaction to our different proposals, but there is no unanimity in the aspects related to the gamification strategies associated with the rewards and the give challenges for their community. The user-centered design methodology proved to be robust to evaluate the proposed gamification strategy, allowing ergonomics to play a fundamental role in the development of an information system, that can prevent the occurrence of problems of acceptance in the future.

Keywords: Smart city · Engagement · Gamification · Mobile application · Ergonomics design

1 Introduction

New technologies, gives the opportunity to citizens to increase their live style and efficiency, creating smart cities and smart citizens. This is particularly important nowadays, considering the rapid urbanization rate the challenges related with socioeconomic, environmental and governance challenges [1].

There are various definitions about what a smart city is, one of the most integrated definition was made by Angelidou [2] including four important cardinal forces for smart cities: advanced human capital (citizen empowerment, intellectual capital and knowledge creation); social capital (social and digital inclusion), behavioral change (sense of ownership and meaning) and a humane approach to change, where technology responds to the needs and interests of the user. Recently, Tan Yigitcanlar et al. [3] in a systematic review of the literature on smart cities, suggested three types of drivers: community, technology and policy, which are linked to five desired outcomes:

productivity, sustainability, accessibility, wellbeing, liveability and governance. The authors suggested that these drivers and outcomes together create a framework to better understand a smart city.

Sensors are essential for developing a smart city, they can take measures from the environment (i.e. temperature, noise, contaminants) and process images in real time in an efficient way. They can have some limitations related with subjective data, that depends from the citizen profiles. For example, safety perception and human emotion and feelings related with events that occurs in the city is not measure by a sensor. Also, some events like holes in the streets and the danger that they can represent cannot be easy to be identified automatically by sensors. In this context, the citizen can be a sensor with a lot of advantages compared to physical sensors. By have the opportunity to share information about good and bad events in the city, the citizen will be engaged and take more responsibility for their individual situation, being involved to contribute to society. Several researchers connect this participation is an important way of enhancing democracy [4–6]. Engage the citizen is not an easy task, they need to spend energy and an amount of time to participate. A way to engage the citizen is through the use of devices that allows the introduction and consultation of information with a good usability. Another complementary way to increase the citizen engagement is the gamification, with incentives to became participant. Smartphones with adequate software provides a way to get data from the citizen, by adding elements of gamification [7]. Gamification was defined in the first time in 2011 from Zichermann and Cunningham [8] as "the process of game-thinking and game mechanics to engage users and solve problems". In this context, they connect gamification with the possibility to involve the consumers in loyalty programs and generate behavior change. A complementary perspective as proposed by Werbach et al. that propose a definition for gamification as a way to bringing fun to obligatory activities. Another perspective as done by Schoech et al. [9] that associate gamification to engage and motivate to a behavior change strategy. Grossman et al. [10] define gamification as the use of elements of video games in non-game situations, to enhance user experience and engagement.

The mixt of the previous perspectives give us the following definition. Gamification is a process that use game mechanics to engage people to accomplish a task to solve a problem, or change a behavior, with pleasure, in a non-game context. This means that gamification might be used in situations where a person needed to accomplish an objective, after developing a set of tasks, but also to change a bad behavior that can affect, for example, the health or safety of a person.

Gamification use renewals (points, rankings, levels, badges, money) and challenges (complete activities and achievements) to motivate the users inside a storytelling to give an objective to interact. Those game mechanics are supported by the human needs related with hedonism (senses stimulation and discovery), prestige (privileges and leadership), achievement (through tasks completion), socializing (cooperation, collecting support) and expression (customization to be different).

According to Marache-Francisco and Brangier [11] the implementation of a gamification strategy needed to be supported by two main requirements: an analysis of the context to identify the main aspects to be considered in the gamification experience

and by an interactive design process, that allow the evolution of the gamification solution by user tests.

Taking this framework as a reference, this study presents a gamification proposal for an ongoing research to develop an online platform for the project smart city sense.

Taking this framework as a reference, this study presents a gamification proposal for an ongoing research to develop an online platform for the project Smart City Sense, financed by the Portugal 2020 program. This project involves the conceptualization, design and implementation of an information technology platform where the wealth of data collected by citizens (volume, variety and detail), is aggregated with data collected by a variety of other existing sensors in the city, giving in real time, a clearer and more vivid vision of the global "pulse" of the city. The platform will also create an adequate environment (physical and virtual) for cooperation between citizens and city authorities enabling that the information added by one part to be available to all stakeholders. This objective proposes an approach to the concept of Smart Cities that puts the citizen as the focal point of the data collection and information sharing process [12].

The first users of this platform will be the security community leaders that live in the various regions of Lisbon. These persons are civil persons that dedicate some of their time to improve the quality of life of the persons that live in their Lisbon region, particularly in relation to security. Because they are special people, we had many doubts about various characteristics of the platform to be implemented. Being people who are more involved in the security aspects of people, we were interested in knowing if they would also be interested in having a comprehensive intervention, also being involved in the conditions of the city that can affect people's health and accessibility and efficiency. Engaging those people in a gamification process was another challenge, we did not know what kind of challenges and rewards (intrinsic or extrinsic) would be most appropriate to motivate then to use the Smart City Sense platform.

2   Methodology

A methodology was based on participants' opinions, through a questionnaire, to be used to evaluate a gamification proposal for a smart city.

2.1   Sample

As explained before, the participants of this study were security leaders of the Lisbon city, that collaborated voluntary in this study. A sample of twenty-three persons, aged between 32 and 66 years (mean age = 45, SD = 6,33), 14 female and 9 males from different zones of Lisbon participated in this study.

2.2   Methodology

A questionnaire was designed to extract the information from the Lisbon city security leaders to propose a gamification strategy for the platform. According to literature review and meetings with the project team, composed by a multidisciplinary group of: ergonomists, psychologists, designers, engineering and sociologists, we elaborate 41

questions in a five-point Likert scale ranging from 1 to 5, where 1 was (completely disagree) and 5 (completely agree), plus demographic data (gender, age and residence). The first question was aimed to confirm the interest to collaborate in a smart city project. The same question occurs in final of questionnaire, to verify if the respondents changed their opinion after answered all questions.

1. I want to be able to use an application that contributes to the efficiency and well-being of the citizen.

   The following three questions aimed to verify the interested of the security leaders to report different kind of problems in the city. Considering that they are more involve with city security, we need to verify if they could be interested to be involved to report problems related with health and accessibility.

2. I would like to be able to use an application to report situations that may affect the security of the citizen.
3. I would like to be able to use an application to report situations that may affect the health of the citizen.
4. I would like to be able to use an application to report accessibility situations that may hamper citizen mobility.

   Considering a situation where the user cannot report an event in-loco, but have the possibility to report later, for example in home, with the following question we want to verify if they agree with this possibility.

5. To report a situation, I want to be able to check the location at the time it happens, but I want to be able to report later at another location.

   Normally, the solutions for a smart city project is dependent of negative events, in this project we want to know if the potential users, agree about the idea to report positive events, related with good things, like those in the following four questions.

6. I would like to be able to use an application to report good things in the city, such as safe streets to drive at night.
7. I would like to be able to use an application to report good city situations, such as clean streets.
8. I would like to be able to use an application to report good city situations, such as beautiful gardens and urban art.
9. I would like to be able to use an application to report cultural events that will occur in my community.

   When the potential user is busy, the motivation to suggest an improvement, after report a problem, could not be the best. But if they are not able to suggest an improvement, they probably will feel less engage to report a problem in the city. The following question access whether the potential user would interest in suggesting improvements solutions for a problem.

10. After reporting a situation, I would like to suggest improvement suggestions through an application.

The notifications sent to users is good provide feedback about the events and occurrences in the city. That information can contribute to engage the citizen in the platform. However, this information could not be intrusive in the life of the citizen. In the next four questions we want to know when and here the potential user want to receive feedback notifications of the platform.

11. I would like to receive notifications about the city in the morning.
12. I would like to receive notifications about the city in the afternoon.
13. I would like to receive notifications about the city at night.
14. I would like to receive notifications when I am away from home.

Considering that the potential users are more involved in security issues we don't know if they are interested to consult other aspects of the city, particularly related with health and accessibility. The following three questions are related with this subject.

15. I would like to consult to security-related situations in the application.
16. I would like to consult to health-related situations in the application.
17. I would like to consult accessibility issues in the application.

How long is acceptable for the user to report in the application a situation in the city? The answer of this question is very important to decide the number of item's that must be filled in the application. If the user needs to enter a lot of information to report an event, he may not feel motivated to post, however, if little information is requested about an event, it will not be possible to understand the situation and determine the best intervention strategy. After a discussion inside the multidisciplinary team work, we decide that two minutes is the time needed to enter the most important information to characterize an event situation in the city. The next question wants to capture the level of agree about this decision.

18. It is acceptable for me to spend 2 min to report a situation in the city.

When the user wants to report an event in a mobile application in the urban context, he needs to play attention to the environment, to avoid safety problems due to a loss of attention to the traffic, for example. In this context, writing text in a mobile application could not be a good idea. However, allowing the user to write a text to explain better the event can be an important information to better understand the event. The next question wants to capture the level interest of the user about their willingness to write a text and/or take a photography.

19. I would like a text area to describe the situation I want to report.
20. It is acceptable for me to photograph with the application a situation to illustrate a report.

In the next question, we want to check the user's opinion, about the time of two minutes to report an event on the platform, would be well accepted by others. The objective is to verify if there are differences between the opinion of him, collected in the question 18 and others, but now in relation to the others.

21. It is acceptable for other people to spend 2 min reporting a situation in the city.

Enter personal information in an application is very important to characterize the user, to send to him the adequate information in function of their needs and preferences. However, this can be critical, as you usually the user do not want to put personal information in the application, due to confidentiality issues. Next two questions collect the level of acceptance that users would be available to provide personal information and preferences.

22. It is acceptable for me to customize my area in an application, according to the following personal characteristics: Name; Age; Profession; Genre; Place where I live; Telephone; Email.
23. It is acceptable for me to customize my area in an application according to the following personal characteristics: Food preferences; How to get to work; Difficulties of mobility.

Next question collects the level of the user acceptance to share theirs reports in the application.

24. It is acceptable to me that other users of the application should consult the situations I have reported.

Normally, the security leaders are only involved in activities their region and don't care about the other regions of the city. In our proposal we are interested to involve those persons not only in their region, but in all other zones of the Lisbon city, through gamification strategies. In the following questions we want to know the motivation of the potential users to report information in their neighborhood and in other communities.

25. Whenever I share situations in my neighborhood, I receive rewards.
26. Whenever I share situations in other communities in the city, I receive rewards.

A good leader must challenge the community members and have the curiosity to know and control the behavior of the other community members. In the following questions we want to know if the security leaders are motivated to use an application to do it.

27. I want to be able to challenge other users.
28. Whenever I share situations, I would like to know how many people have reported this situation.

Extrinsic rewards, such as relating to receiving points or stamps for reporting events, is a way to create user engagement mechanisms. In the next question, we are interested in hearing the opinion of the community safety leaders on this aspect.

29. When I share information in a community for the first time: I would like to receive a virtual stamp (with graphic elements of the community) in a virtual carnet until I complete the 24 parishes of Lisbon.

The visual identity of an application is very important to be easy recognized and accepted by the potential users. In our application to the smart city sense platform we want to know it the landmarks and traditional parties in the city could be used to accepted by the security leaders.

30. It makes sense for me that the application has for the city of Lisbon have graphic elements of identity allusive to: popular parties and monuments, for example, Lisbon castle.

The balance between intensity of the challenges and the rewards types, are very important to engage the potential users to post and consult information in a smart city. In the next two first questions, we want to know: when and the feedback type for the security leaders. We also developed a set of questions to evaluate the relative importance that the security leaders give in relation to different of rewards (personalized information, feedback, status, credibility and distinction, be able to give challenges).

31. When I share a situation in a community for the first time: I want to receive personalized information about this parish.
32. When reporting a situation, about a city problem that has a possible resolution: I would like to be informed about updating my report.
33. Based on my use of an application, I would like to be able to evolve my status in the city, as follows: 1st level: Discovering the city; 2nd level: Attentive; 3rd level: Active; 4th level: Proactive; 5th level: Recognized; 6th level: Caretaker; 7th level: Exemplary.
34. In view of the veracity of the shared information, I would like to be able to develop credibility, in order to distinguish myself from other users, as follows: Negative level: Speculator; 1st level- Dedicated; 2nd level- Integral; 3rd level- Consistent; 4th level- Sincere; 5th level- Reliable; 6th level- Issue
35. When I report situations in a community, I would like to be able to evolve within the parish, distinguishing me from who contributes more or less, as follows: 1st level has 1 star … 5th level has 5 stars

Who can challenge other citizens? The status of a person is a very important factor, so that the citizens of a community can accept and implement the challenges posed. The next question is intended to assess the opinion of potential users if a high individual status in the program can pose challenges to other community members.

36. At 5th Level (5 stars) I can challenge other members of the parish group using the application.

In the following two questions we want to know if the security leaders want to receive rewards, related to other activities that are not directly connected to report or consult information using the application.

37. With my use, I want to receive mini-games where I can earn more points for my status.
38. When I walk next to an emblematic site, I want to receive information on this site in an application.

The possibility to have links to share the personal performance in the networks could be a good feature to improve the application engagement, but some people don't want to be exposed online. The next question evaluates the degree that the security leaders want to share their performance in internet.

39. I would like to be able to share my performance using the application on social networks.

The penalties are part of the gamification process and aim to keep people in the application. In this context, we were interested to know the reaction of the user when he loses status if do not use the application for a period of one month.

40. If I do not use the application for a month, I agree to lower my cumulative status.

The last question, which is the same as the first question, seeks to verify whether people have changed their minds about the use of application after completing the questionnaire.

41. I want to be able to use an application that contributes to the efficiency and well-being of the citizen.

2.3   Procedures

The participants (security members leaders) were invited to a meeting with the objective to collaborate, as potential user in the development of the concept of an application do share and consult information about Lisbon city.

In the first part of the meeting, we explained the importance of the project Smart City Sense and the need to involve then in a user centered design perspective in the development of an application where they can share and consult information of the city.

Next, we show an example of completing the questionnaire with a question and asking if there were any questions, before fill the questionnaire.

3   Results and Discussion

The results will be presented for each question and discussed its suitability to the application gamification project that supports the platform.

Questions 1 and 41: I want to be able to use an application that contributes to the efficiency and well-being of the citizen (mean 4,65: max. 5, min. 3, for the first question) and (mean 4,7: max. 5, min. 3, in the last question).

These results show that the potential users accept to use an application to report and consult information to contribute to the citizen efficiency and well-being. It is also verified that after completing the questionnaire, where they knew of some character-istics of this application, the results were not altered.

In conclusion, in general the potentials user accepts the possibility to use an application.

Questions 2, 3 and 4 – report respectively, problems with security (mean 4,7: max. 5, min. 3), health (mean 4,67: max. 5, min. 3) and accessibility (mean 4,74: max. 5, min. 3).

During the questionnaire preparation meetings, doubts were raised as to whether security community leaders would also be interested in reporting health and accessi-bility issues. The results showed that they are very interested in reporting, without

distinction, situations that could compromise the level of security, health and accessibility of the citizen.

Those features will be implemented in the application.

Question 5 – report a situation later in another location (mean 4,43: max. 5, min, 3). The potential user doesn't see any problem to have the possibility to report a situation in the application in another location. This feature will be implemented in the application, georeferencing the location and later, asking if the user wants to report this situation.

Questions 6 to 9 – Use the application to report positive events: safe streets (mean 4,52: max. 5, min. 3); clean streets (mean 4,30: max. 5, min. 2); beautiful gardens (mean 4,13: max. 5, min. 2) and cultural events (mean 4,26: max. 5, min. 1).

In general, users accept this idea, however, in a less intense way, compared to the one used in the application to report problems. Particularly, the aspects related to beautiful gardens and cultural events, had some answers less than 3.

Although there is not a very strong consensus in all these aspects, we think that these characteristics should be implemented in the application.

Question 10 – report suggestions through an application (mean 4,35: max. 5, min. 3).

Although not very strong, the big trend is to be able to use the application to suggest solutions for a given problem. Knowing that in urban space, after reporting an event, it may be difficult to type a solution in a smartphone, we will propose an option that allows the user to fix the solution later, at a more appropriate time and space.

Questions 11 to 14 – receive notifications about the city in the morning (mean 4,17: max. 5, min. 3), afternoon (mean 3,9: max. 5, min. 2), at night (mean 3,78: max. 5, min. 1) and away from home (mean 3,70: max. 5, min. 1).

While most of the potential users accept receiving notifications at any time of the day and even away from home, the big trend is to receive these notifications in the morning. Regarding the location where they can receive the notifications, particularly, out of the house, some users expressed discomfort referring that they feel controlled by the application. In conclusion, it is important to inform users that for this application function, it is necessary to know their location to send notifications and that all information collected is confidential. The user will also be allowed not to allow the application to know her location.

Questions 15 to 17 – like to consult: security-related situations (mean 4,61: max. 5, min. 3); health-related situations (mean 4,26: max. 5, min. 2); and accessibility issues (mean 4,43: max. 5, min. 2).

Potential users prefer to consult information related to security aspects, however, they have also shown interest in consulting information related to health and accessibility. In this case, the doubts that arose during the development of the questionnaire that the community security leaders would not be interested in consulting problems other than the safety aspects is not true.

Question 18 – Two minutes, as the acceptable time to report a problem (mean 4,3: max. 5, min. 1).

Although most users accept as appropriate two minutes, as the acceptable time to report an event, two people have stated that it is a very high time. This problem will be discussed later in question number 21.

Questions 19 and 20 – Need an area to describe the situation (mean 4,43: max. 5, min. 3) and take a photography (mean 4,61: max. 5, min. 3).

Either of these situations are acceptable to potential users, although they are more likely to illustrate the event with a photograph than with a description of a text. In this case, regarding the text and considering the difficulties in entering text on a smartphone in the urban space, as well as the situation of danger to the user that this situation entails, our proposal will be that the text entry can be done later, in another space and time.

Question 21 - Acceptable for other people to spend 2 min reporting a situation (mean 3,7: max. 5, min. 1).

Compared with question number 18, where potential users are asked if two minutes would be adequate time to report an event in the city, this question was referred to a lower value (mean 4,3–3,7), this mean that they are not sure that two minutes is an appropriate time to report an event in the city.

We think that despite this trend, more studies need to be done to know the appropriate time to report an event with a smartphone in urban space.

Questions 22 and 23 – Customize the application with personal demographic characteristics (mean 2,70: max. 5, min 1) and personal characteristics (mean 3,09: max. 5, min 1).

In general, potential users are unwilling to provide personal data that allows customization of the application. Knowing that this information is very important for the stratification of people and in particular for sending personalized information. Our opinion is that this information should only be requested later, when the user relies on the application and can be comfortable at ease. Whatever the situation, this information should never be considered mandatory.

Question 24 – Consult the user reported situations (mean 3,78: max. 5, min 1).

This situation has not met the consensus of all potential users of the application, two participants refer their complete disagreement in allowing others to consult their reported situations. In this context, our proposal is that, by default, the information relating to the events reported is confidential, allowing however that at the user's choice, this information may be public.

Questions 25 and 26 – receive rewards to post events in neighborhood (mean 3,22: max. 5, min 1) and in other communities (mean 2,87: max. 5, min 1).

In general, potential users are not interested in getting rewards, to report events in the city, particularly if they are in regions other than their own. We think that this reaction is due to the fact that they think that the rewards are always extrinsic, receiving money, for example. As citizens, who voluntarily dedicate themselves to preserving the security of their region, the financial aspects are not the reason to report events in the city.

Questions 27 and 28 – challenge the others (mean 3,23: max. 5, min 1) and control the citizen reports (mean 4,42: max. 5, min 2).

The results show that community safety leaders are not interested in challenging community members. This result can be a problem for the application, because without users motivated to challenge citizens and thus involve more users, the application may not succeed in the future. In this context, it will be necessary to try to quickly find good strategies that motivate leaders to introduce challenges to the citizen to create

mechanisms of engagement and with that, to retain users and to increase the user community.

Question 29 – after report an event receive a visual stamp (mean 2,61: max. 5, min. 1).

The result showed once again that community safety leaders are not interested in receiving extrinsic rewards, so this will not be the best strategy to motivate them to the application.

Question 30 – application using graphic elements allusive Lisbon parties and monuments (mean 3,78: max. 5, min. 1).

Despite being well accepted by the majority, some potential users express the displeasure in associating the application with elements of the identity of Lisbon. We think that this opinion may be related to the fact that the people who answered the questionnaire are only concerned about their region and not interested in mixing other regions. This should merit further investigation.

Questions 31 to 35 – after report an information in the application, receive renewals: personalized information about the community (mean 3,65: max. 5, min. 1); be informed about updates of the report (mean 4,65: max. 5, min. 1); increase status (mean 3,78: max. 5, min. 1); increase credibility (mean 3,57: max. 5, min. 1); distinguishing (mean 3,61: max. 5, min. 1).

Although the results are positive, there is not a very strong agreement on these rewards, some users reported negative opinions regarding this strategy. The highest result is related to receiving updates on the events reported, however, rewards related to status, credibility and distinction were not highly valued by those who answered the questionnaire.

More studies should be done on this topic to see if these users are more interested in other types of rewards given their special community security leader profile.

Question 36 – Challenge the other members of the community using the application (mean 2,96: max. 5, min. 1).

This result shows that the five-star status in the application is not well accepted to allow the launching of challenges to other members of the community. It is recalled that in question number 27 in which potential users have expressed no interest in challenging other members of the community. More research is needed to find the best way to engage leaders to challenge other members of the community.

Questions 37 and 38 – play a game to get more status in the application (mean 2,61: max. 5, min. 1) and receive information personalize information in the city (mean 3,48: max. 5, min. 1).

Users of this application, who responded to this questionnaire, do not want to use an gaming entertainment application, even if it is to increase the status. Regarding the personalized information in the city, there was also no response from the people who answered this questionnaire (community security leaders) a great interest in receiving personalized information about the regions of the city.

Question 39 – share personalized performance in social networks (mean 2,57: max. 5, min. 1).

People who answered the questionnaire are not interested in sharing the events they reported in the application on the platform.

This view is consistent with previous responses, where respondents did not demonstrate the need for their information to be disseminated to others in the application.

Question 40 – lower the cumulative status if not use the application (mean 2,70: max. 5, min. 1).

Although they consider that status is not very important in this application, people who answered the questionnaire do not want to lose status.

4   Conclusions

This study uses a user-centered design approach to evaluate a gamification strategy for a Smart City Sense platform application. The study was developed with the first population which will use this application, citizens who voluntarily are leaders their local community, with tasks related to people security. In general, this special population has a positive reaction to our different proposals, but there is no unanimity in the aspects related to the gamification strategies associated with the rewards and the give challenges for their community.

In general, the user-centered design methodology proved to be robust to evaluate the proposed gamification strategy, allowing ergonomics to play a fundamental role in the development of an information system, that can prevent the occurrence of problems of acceptance in the future.

Other studies should be developed to evaluate whether the same strategies can be applied to the general population, which have different characteristics from the one that participated in this study.

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