Masters Program in Geospatial Technologies

COLLECTING DATA FOR INDOOR MAPPING OF THE UNIVERSITY OF MÜNSTER VIA A LOCATION BASED GAME

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Dissertation submitted in partial fulfilment of the requirements
for the Degree of *Master of Science in Geospatial Technologies*

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DECLARATION

I declare that this thesis entitled “Collecting data for indoor mapping of the University of Münster via a location based game” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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KEYWORDS

Location Based Games
Crowdsourcing
Gamification
CampusMapper
Indoor Mapping
Mobile application
Volunteered Geographical Information
Android Applications

KEYWORDS (Spanish)

Juegos basados en localización.
Crowdsourcing
Gamificación
CampusMapper
Mapeo de interiores
Aplicación móvil.
Información Geográfica Voluntaria
Aplicaciones Android

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ABSTRACT

Nowadays the collection of spatial indoor mapping data presents a big challenge for both science and industry because there is not a cost-effective method yet for it as it is for outdoor mapping. Research is pointing out to crowdsourcing as means of address the challenge of massive indoor mapping based on the principle that people should be the main source of information. Therefore the crowd needs a tool that lets them do indoor mapping tasks as well as means of motivation. This project has as its main goal to study the impact of gamification as a motivation factor by implementing and evaluating it in a mobile application aimed for acquisition of indoor spatial data of the buildings of the University of Münster. For this purpose an already existing mobile application was modified to incorporate game elements, thus creating a new version of the app. Three game mechanics were added for the new version of the app: score, leaderboard and conquest map. Once both apps were ready (gamified and original non-gamified) an evaluation was carried out with 28 participants (14 male and 14 female) to assess the impact of game mechanics when users are performing indoor mapping tasks. As a result we may say that the most of participants preferred the gamified application over the non-gamified one, the study also shows that actually men favored the gamified app more than women.

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1 INTRODUCTION

Nowadays, to have available spatial data in digital coding of the interior of buildings, both their geometric structure and semantics is the basis for the development of applications in different areas such as navigation and routing, emergency response or accessibility. Unlike outdoor spatial data, indoor data collection presents new technical and social challenges. Some of those social challenges are that indoor data mapping or its maintenance is not yet a responsibility for public agencies and information is inherently private (Rosser et al., 2012). As technical challenges we may say that still there is not a cost-effective method to collect indoor data as is remote sensing for external environments, and building models by nature need are three-dimensional. Therefore it presents a challenge in terms of finding the best strategy for massive indoor mapping, the users that daily visit the buildings could be the best source of information to collect and maintain data related to the interior elements of the building, they know about different levels of accessibility and understand roles fulfilled by particular areas (Rosser et al., 2012).

In the book Wisdom of crowds (Surowiecki, 2005) many examples are mentioned about the high degree of accuracy in the answers that the crowd, the general people gives to certain problems. One of the concepts applied in this project is crowdsourcing and more specifically Volunteered Geographical Information, known as VGI (Goodchild, 2007). One of the most popular applications in this area is Open Street Maps (OSM), which has greatly facilitated the outdoor mapping by the notion that GIS should be resident-generated (Talen, 1999). The question today is how to apply those concepts but for indoor mapping. Currently, the building footprints in OSM surpassed the amount of data on streets (Goetz and Zipf, 2012), which seems to indicate that the next step is to map the interiors of those buildings. This need of information coupled with the tendency of mobile devices to have more and more accurate sensors is one of the main motivations to build a tool that tie these two aspects. On the other hand, since we suggest that users of a building might be the main source of information, then comes up the next question about how to make them contribute with that information? (Buecheler, et al., 2010) suggest that users could participate not only for monetary rewards, but for intrinsic motivations as well, like simple fun. Therefore we decided to try gamification approach (Deterding, et al., 2011), as a possible method to engage people to join the massive task of indoor mapping.

Research Question: Do the gamification elements in an indoor mapping application encourage users more to perform mapping tasks than if using an application without gamification approach?

Goal: Study the impact on user when gamification is applied to a mobile application aimed for acquisition of indoor spatial data of the buildings of the University of Münster.

This project applies gamification and crowdsourcing to a mobile application or app that was developed at Institute for Geoinformatics (IFGI) designed to collect indoor mapping data from the buildings of the University of Münster, it is called *CampusMapper* and works for android mobile devices with touch screen capabilities. The process is taking a photo of the building floorplans and then users are able to overlay the floorplan with features like doors, rooms and stairs. All this elements are saved as geometric and semantic information to an Open Linked-Data database called LODUM (http://lodum.de/).

In order to apply gamification approach on the previous *CampusMapper* app, a new version of the application was created with new characteristics added to it in order to make the application behave as a game which basically offers a score for the data that users enter about the building and then as more score they have, the bigger is the number of buildings they virtually own, represented with marks over the buildings locations on a map of the city of Münster, an explanation with more detail is provided chapter 4. By having two fully functional mobile applications, an evaluation process was carried out with questionnaires in order to identifying which app is the most preferred by users after five minutes try of both versions.

As an outcome of this thesis project there are basically two products, one of them is a new version of the CampusMapper application, a gamified one that includes 3 game elements: score, leaderboard and conquest map. The second product is the analysis of the data collected from users via questionnaires after five minutes try of both versions of the app. Results showed that the first impression of participants was to prefer the gamified version of the app, being this preference a little bit higher in male subjects that in female.

The rest of the document is organized as follows: chapter 2 is related work, has four sub-sections of topics closely related with the project, that are mapping, crowdsourcing, gamification, similar applications and evaluation. Chapter 3 contains the description in detail of the methodology. Chapter 4 is the approach of the application; it means the design process of rules, mechanics and interface. Chapter 5 talks about the technical implementation of the app. Chapter 6 contain details about the evaluation process with participants. Chapter 7 shows the results of the data collected from users. Chapter 8 brings up the discussions around the limitations found in the app's implementation, evaluation and results; and finally Chapter 9 contains the conclusion and future work that may be continued from this work. Appendix 1 has the step by step instructions for the experiment and Appendixes 3 and 4 contain the questionnaires applied to participants.

2 THEORETICAL FRAMEWORK

This chapter provides an overview of the work conducted in the topics related with this thesis project as well as the main conceptual definitions. It is organized in six sub-sections, 2.1 presents and introduction on indoor mapping, its standards and models. 2.2 give us an introduction on crowdsourcing, covering definitions and the importance of this approach in the scope of a massive indoor mapping. On the next sub-section, research on gamification and its principles is covered. A summary of some applications developed with the purpose of getting spatial data by using or not gamification are made available in sub-section 2.4. A summary of evaluation methods and scales is presented in sub-section 2.5. And finally, in last sub-section we provide an overview of all the topics discussed in this chapter.

2.1 INDOOR MAPPING

Indoor space has several differences with outdoor space; these main differences are architectural components that constrain the space like doors, stairs, floors, corridors, walls, etc. (Li, 2008). Spatial outdoor information is mainly represented by two-dimensional technology, but when we approach indoor information then third dimension (3D) is needed to represent the spatial data, this dimension is handled as the assumption of elevation as function of location, which is called in literature as 2.5D. In (Goodchild, 2010) is stated that progress towards a truly 3D Geographic Information System still remains slow by the lack of cost-effective technology for data acquisition and indoor positioning as remote sensing or GPS respectively. Besides these limitations, Goodchild poses a question as an example of the unresolved issues to reach 3D approach: “Is a building better modeled as a set of walls in 3D, or as a linear network of nodes (rooms) and links (doorways, hallways) embedded in 3D?”, the second option in the inquiry is actually the approach used in this project, a building modeled as a network of nodes and links.

In order to represent, store and exchange 3D city models, including buildings, there are some models of representation, one of the most widely known is the XML-based encoding model CityGML (http://www.citygml.org/) that started out on 2002 which contains specification for entities in an urban environment. On the other hand IndoorGML (Li & Lee, 2010) is a new XML-based candidate OGC (Open Geospatial Consortium) standard proposed in 2012 explicitly for indoor environment, which combines 3D standards as CityGML with additional features: geometric graph for navigation and multi-layer space model (see figure 1) but does not contain geometry for indoor spatial objects. However, geometric representation in IndoorGML is defined by ISO 19107 (http://indoorgml.net/).

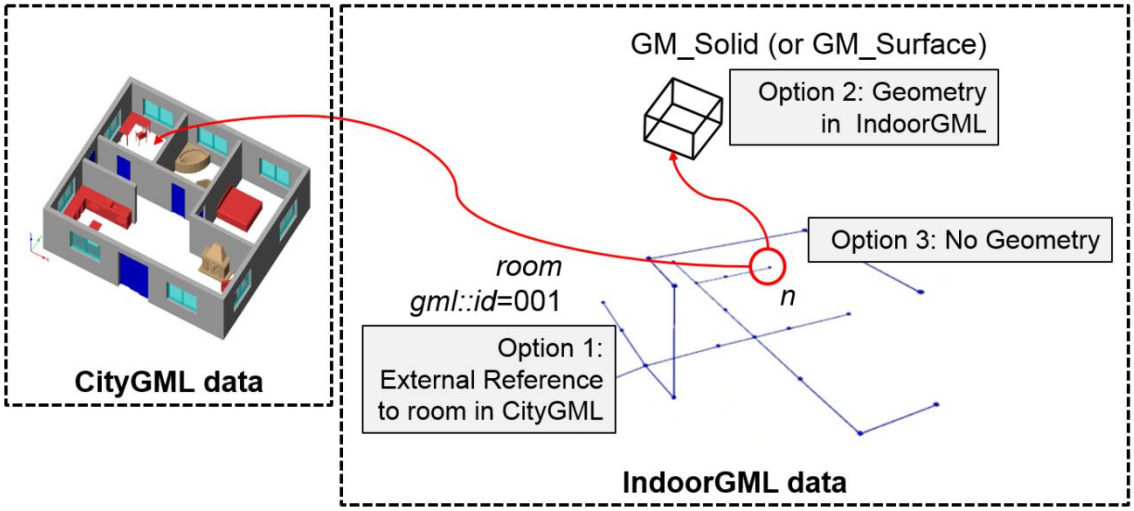

Figure 1: Geometry in IndoorGML (http://indoorgml.net/)

The standards mentioned above solve the problem of indoor space models and representation, but still another big challenge is unsolved, the data collection. One of the first approaches to automatize indoor data gathering was the robot mapping (Thrun, 2002) (Hähnel et al., 2003) which basically consists in a robot equipped with sensors to perceive the outside world, sensors like laser range detectors, infrared, cameras, etc. A new technique is the use of RGB-D cameras to capture RGB images along with per-pixel depth information and then build dense 3D maps of indoor environments. (Henry et al., 2012)

At the end of 2011 OSM launched IndoorOSM which is a tagging schema for indoor mapping following OSM methodologies; it means two dimensional geometries with additional metric or semantic information (Goetz and Zipf, 2012). In order to collect de data an OSM editor like JOSM is available, which works based on building floorplans pictures (https://josm.openstreetmap.de/). IndoorOSM uses similar ontology as used in our thesis project, for example they also use entities like building level, elevator, and corridor. Although the data representation in a geometric model is out of the scope of our project, it is important for us to understand which data makes sense to represent and by which means. Our application saves the spatial data as coordinates that represent points and lines, as well as some semantic information.

2.2 CROWDSOURCING

The term of “crowdsourcing” was first coined by (Howe, 2006) in “The rise of crowdsourcing” and gives us an idea of crowdsourcing as coming from the term “outsourcing”, but in this case the work that normally is outsourced, now is send to the crowd (everyday people). Two concerns arise from this definition; the first one is about

the accuracy of the work that is provided by the crowd and the second one is about the motivation for the crowd to participate. (Surowiecki, 2005) mentioned the TV show *Who Wants to Be Millionaire?,* where random people sitting in a TV studio picked up the right answer 91% of the times which make us think about the high intelligence of the crowd. Regarding of what could motivate the contributions of this group of random people, (Buecheler, Thierry, et al., 2010) suggests that individuals do not participate only for monetary rewards, but also for inherent motivation as just have fun.

Nowadays, how to do a massive mapping of spatial indoor data still represents a big challenge, since there are no public agencies to perform this job as we have for outdoor spatial data. Therefore one of the most interesting approaches is the use of the crowd to accomplish with this mission. (Goodchild, 2007) uses the term "volunteered geographic information (VGI)", which may be understood as the crowdsourcing applied specifically to spatial information. Good examples where these discussed definitions are successfully applied are websites as Wikimapia (http://wikimapia.org/) and OpenStreetMap (www.openstreetmap.org).

This project uses the approach of crowdsourcing in a gamified mobile application aimed to collect indoor spatial information. The idea is that everyday users, of the buildings of the University of Münster, could be the best source of information.

2.3 GAMIFICATION

"*The human brain is mostly a voracious consumer of patterns, a soft pudgy gray Pac-Man of concepts; Games are just exceptionally tasty patterns to eat up*." (Koster, 2010)

In (Luis Von Ann, 2006) the author used the term "Games with a purpose" as an approach of using games to solve massive computational problems; they created a computer game called *ESP Game* (Luis Von Ann, 2006) intended to label random images. At that time they focused games with a purpose on solving issues in areas like computer vision, security or content filtering, they did not mention the use of games to help in collecting spatial data, not even in the potential applications of future games section.

In (Deterding, et al., 2011) came with the definition for the term "gamification" and indeed it is the most widespread one so far: "The use of game elements in non-game contexts". Another definition was provided by (Hamari, et al., 2012) from a perspective of service marketing: "A process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation". Beyond of that definition, gamification is a term that is still in debate and sometimes the boundary between something that is "gamified" and a "game" can be blurry since it depends on the perspective of each user, (Deterding, et al., 2011) gives as example the application

Foursquare (https://foursquare.com/) which is a web application that uses game elements, even though people may say they are “playing” or “using”. In figure 2 gamification is separated from other terms as “Serious games” (Michael & Chen, 2005) and “Playful Design” (Ferrara, 2012) and situated between the game and play, the whole and parts.

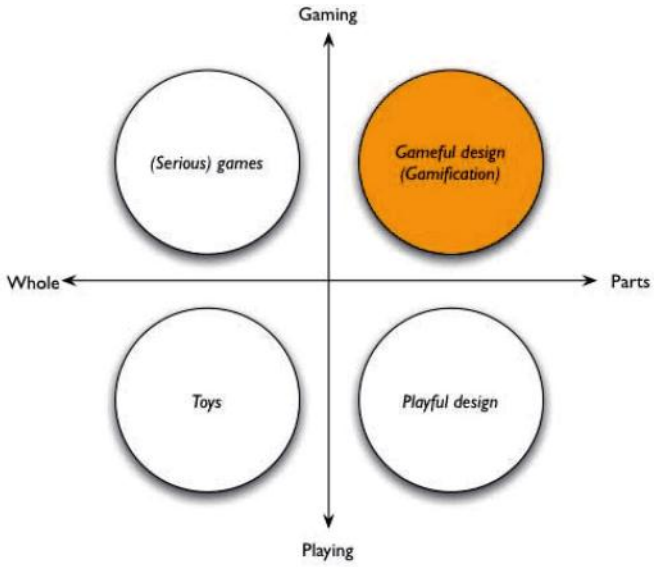

Figure 2 - Situating gamification (Deterding, et al., 2011)

In general terms, the ultimate goal of gamification is to engage the participation of people by giving them the option of having fun or play in a non-gamified context. Literature suggests positive effects of gamification; nevertheless according to (Hamari, et al., 2014) there are two key factors for the success of gamification: the context and quality of users. Decent examples of achievement of gamification are applications like Foursquare (https://foursquare.com/) and foldit (http://fold.it/portal/). One of the challenges of performing indoor spatial mapping by using CampusMapper mobile application is actually to encourage more people to use the application and that is why we implemented the new version of the application in the scope of gamification.

2.4 RELATED WORK

In the literature there are several applications with similar approaches as CampusMapper, the application we are using as base of this project. Let’s take a look to some of these applications:

Urbanopoly (Celino, et al., 2012) in a mobile application in the context of games with a purpose and VGI. Its design is based on the idea of the famous board game "monopoly" and it is aimed to correct and collect new datasets of outdoor spatial information. As game elements they use basically four: the wheel of fortune to assign missions, a leaderboard, virtual money and a map that shows the portfolio with venues, these venues are real places like monuments, restaurants and shops. The application was released into the wild through GooglePlay and monitored during one month. They obtained positive results: data precision 92% of accuracy, average life play of 100 minutes, which they said means the players enjoyed the game. Our application *CampusMapper* has similar characteristics as *Urbanopoly*, even in the data storage they also use open linked data (Celino, 2013), and the main difference is that our application is aimed for indoor mapping, even though their results actually suggest that gamification and crowdsourcing are an encouraging approach to collect spatial data.

Another interesting mobile application is *CrowdInside* (Alzantot & Youssef, 2012) that uses crowdsourcing approach; basically the users do not need to interact with the app, just have it activated and by using the sensors of the mobile device movements of the users are traced to generate automatic building maps as showed in figure 3. The difference with our applications is that they can't enter semantic information about building elements.

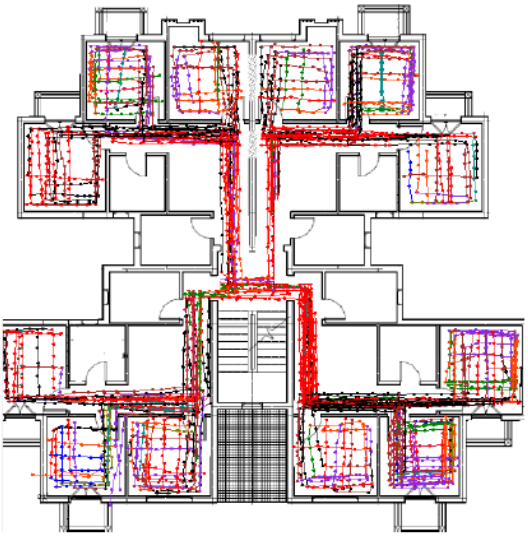

Figure 3 - Motion traces inside a building. (Alzantot & Youssef, 2012)

CityExplorer (Matyas, et al., 2008) is a gamified web application with a mobile component that collects outdoor spatial information and it was played in teams of 4 people at the same time in two different cities, one in Germany and the other in Japan, they claim to obtained optimistic results in terms of number of markers collected, 772

markers in 20 days. Although this application applies gamification, it is aimed for outdoor data and of course at that time sensors of mobile devices were not ubiquitous and accurate as they are now. Gamification was also applied in *panOULU Conqueror* (Tiensyrjä, et al., 2010), which score points by conquering the real-world access points of a large municipal wireless network, the game was empirically evaluated with a four-week long tournament involving 96 players in 31 teams, they found that location-awareness combined with a rather modest level of pervasiveness can go a long way in creating engaging gaming experiences. Positive results in these applications suggest that gamification and crowdsourcing are encouraging approaches to build applications to collect spatial data.

2.5. EVALUATION

Even when evaluation of usability is not part of this thesis project, it may impact the study in the way the participants perceive usability of our mobile application. When researches assess usability this may be carried out in a laboratory or on the field, according to (Kallio & Kaikkonen, 2005) laboratory testing is enough when studying interface and navigation issues but field tests are worthwhile when combining usability tests with a field pilot or contextual study where user behavior is investigated in a natural context. In our case we are studying gamification applied in a mobile application, a field testing should be preferred instead of laboratory test.

When comes to measure success of games, enjoyability is one of the key parameters to take into account. Flow (Csikszent, 1991) is a widely accepted model of enjoyment; in the contexts of games there are some models to evaluate enjoyment, as is GameFlow, which consist of eight elements: concentration, challenge, skills, control, clear goals, feedback, immersion, and social interaction. In “Feeding Yoshi” (Bell, et al., 2006), a location based game whose degree of success was evaluated by measuring the maximum time a player of each team spent playing in one turn per day and daily average numbers of game plays per player. Landing on gamification or games with purpose enjoyment is difficult to evaluate and depend on each game design, average lifetime play (ALP) is used in many cases as an indicator of enjoyment, this is the overall amount of time the game is played by each player averaged across all people who have played it (Von Ahn & Dabbish, 2008). In gamified applications one of the metrics needed to know is the expected contribution that indicates the average number of problem instances a single human player can solve by playing a particular game. Expected contribution is defined throughput multiplied by ALP, being throughput the average number of problem instances solved per human hour.

In order to evaluate subjects there are three types of research, observational, quasi-experimental and experimental design. The first one is define by the fact that the investigator cannot directly manipulate the variables, on the other hand experimental

methods allow the researcher manipulate one or more independent variables and together with some objective measurement (Field & Hole, 2003). Within theory of experimental design there are two extreme approaches, between-group and within-subjects, the first one uses separate groups of individuals for each condition, the second one, within-subject each individual is exposed to all conditions in the experiment. As part of our evaluation, we are interested in within-subject method, because in that way participants can experience the two conditions: gamified and non-gamified approach. Also this may be evaluated by using heuristics and a user questionnaire, a research in a gamified application EGameFlow (Fu, et al., 2009) suggests that survey can be used along with heuristics to gain an insight to the users' opinion. On the other hand they found that heuristics introduce subjectivity of researcher and are more expensive than use surveys. Therefore Questionnaires is one of the evaluation tools we will use to assess the user preferences.

2.6. SUMMARY

In summary, indoor mapping still represents a big challenge for the academia and industry in terms of collect accurate data in a cost-effective way. Great progress has been done in the field of representation of indoor spatial data in the latest years with standard models like CityGML (http://www.citygml.org/) and IndoorGML (Li & Lee, 2010). One of the actual trends to collect indoor spatial data is the use of software applications framed by concepts as gamification (Deterding, 2011) and VGI (Goodchild, 2007). Those concepts have been already several successful tried in applications like foursquare (https://foursquare.com/), foldit (http://fold.it/portal/), *Urbanopoly* (Celino, et al., 2012), *CityExplorer* (Matyas, et al., 2008) and *panOULU Conqueror* (Tiensyrjä, et al., 2010) and many others.

3 METHODOLOGY

In order to look for an answer to our research question and accomplish our goal of study gamification as a novel approach to motivate people to perform indoor spatial mapping tasks via a mobile application we need to set up an environment where we can observe both digitized indoor spatial data and user behavior by interacting with mobile applications such that concepts of gamification and crowdsourcing are combined. To reach the configuration of that environment what we did is to implement a gamified mobile application based on another mobile application aimed to map indoor spatial information of the buildings of the University of Münster. Then by having two applications in hand (gamified and non-gamified) we can test the preference and engagement of users with indoor mapping as well as to observe the digitized indoor geometric and semantic information.

In the context and the scope of our mobile gamified application we have different parameters and constraints: users are basically the students and any other people that frequently use the building facilities of the University of Münster. Technological constraints are also taking into account since the application has to be designed and developed for mobile devices using free software tools, an internet connection is needed as well. Inputs refers to semantic and geometric data about the internal physical structure and organization of the building such as floor number, rooms, doors, corridors, office number, etc. Outputs are the referenced information that let us generate and/or update indoor maps of the buildings, this output is not visible for users, but is what the application produce and store in the database. This project is for now constrained only to the buildings of the University of Münster.

This methodology is summarized in three steps: the first one states why and how we implement gamification, second one take a look to user interactions with game mechanics and the last one is the evaluation of user preference. Figure 4 shows an overview of this methodology.

3.1. IMPLEMENTING GAMIFICATION

To be able to evaluate the impact of gamification we implemented this approach by adding game elements to our base mobile application *CampusMapper* in order to reach a meaningful gamification as explained in (Deterding, 2011) and (Nicholson, 2012). Game elements are represented in game mechanics in order to understand them and how they motivate users. Besides those principles, other factors were taken into account in order to choose the game mechanics, like technical limitations of mobile devices e.g. the size of the screen and performance. Therefore the implemented game

mechanics were: score, leaderboard and conquest map. A more detailed explanation is provided in the next chapter.

3.2. INTERACTION

By assessing the user interaction with game mechanics and the quality of indoor data collected by those users we may be able to come up with a conclusion whether gamification actually engage users or not, and even when it does this is still useless unless data quality in terms of accuracy and reliability is acceptable, to evaluate data quality we rely only on personal observations. A more precise approach to evaluate quality of geometric indoor data is the construction of 3D models based on the data collected which is out of the scope but suggested as a future work.

Once the gamified mobile application is implemented, and named *CampusMapperGamified*, we are able to observe the interaction of users (students of University of Münster) with both versions of the application; these interactions mainly consists of taking a picture of a floorplan in a given building and then collect indoor spatial data by actions like finger swapping or tapping over the entities identified in the floorplan, such as doors, rooms, corridors, entries, etc. Afterwards all that information is uploaded to a database. The way that user interacts with game mechanics may tell us in which degree the user is motivated to contribute more indoor information. More detail is provided in the chapter 4.

3.3. EVALUATION

CampusMapper app is meant for students of the University of Münster, so for the evaluation of the impact of game mechanics and geometric data quality an experiment is set up with 28 students picked up randomly from the Institute for Geoinformatics and the main library, having 14 female and 14 male individuals. Later on we identify the profile of these students related with their background in computer games and gamified applications, (Hamari, et al., 2014) says that there are two key factors for the success of gamification: the context and quality of users, then by identifying the user's profile we also may be able to identify the quality of users in terms of their profile associated with their contribution through the application.

Every participant was hand out an android mobile smartphone with both applications, following a counterbalanced order to avoid influences from one application to another; after they used the apps, a questionnaire was carried out to assess the impact of the game mechanics on the preference and enthusiasm of participants while doing indoor mapping. Evaluation process in detail is explained in chapter 6 and results are analyzed in chapter 7.

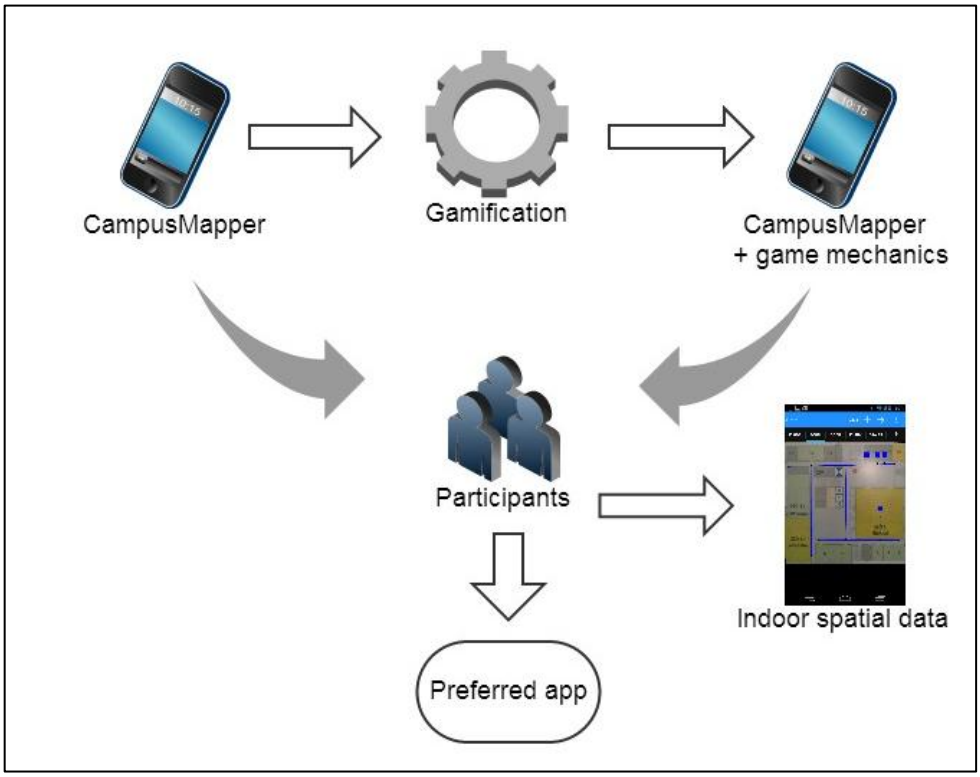

Figure 4 - Methodology

4 APPROACH

As mentioned in subsection 2.3 literature shows that gamification has proven to bring positive results in terms of engaging users, also called players, to perform tasks in the non-gamified context, basically when we apply gamification to some application we are looking to introduce “fun” for users, which is just another word for learning (Nicholson, 2012). Therefore the challenge is how to integrate some of the principles of gamification (Deterding, 2011) into our mobile application *CampusMapper* which has as its main objective the collection of indoor spatial data from the floorplans of the buildings of the University of Münster. These principles according to Deterding are three: Meaning, which suggests that user should be able to bring its own goals to the gamified application where the fundamental idea is to connect the curiosity, passion that the player already has in life, for example meaningful communities with participation player gains reputation and responsibility, the website stackoverflow.com is a good example of this; Mastery, the player should be able to reach a mastery from failures and experience with the application, which at once should give different levels of challenges; and Autonomy, where the player should voluntarily choose to do some task and share goals with others but at the same time have an individual pursue.

According to (Nicholson, 2012), meaningful gamification encourages a deeper integration of game mechanisms into non-game contexts, rather than implementing just a points system, it also recommend to take into account aspects of the underlying activity to understand where an integration of game elements makes sense. (Reeves and Read, 2009) identified the ten ingredients of great games: Self representation with avatars; three-dimensional environments; narrative context; feedback; reputations, ranks, and levels; marketplaces and economies; competition under rules; teams; parallel communication systems, and time pressure. Unlike “serious games” gamified applications merely integrates game elements, also called game atoms (Brathwaite & Schreiber, 2008), into applications that are out of the gaming context. In (Deterding, et al., 2011) identified game design elements on varying levels of abstraction, ordered from concrete to abstract, five levels can be distinguished, see table 1. All of this leads us to a big question, which game elements, through which game mechanics, should we implement in the new version of *CampusMapper*, called *CampusMapperGamified*, and why? Of course we have some constraints due to the timeline of this project, mobile device performance and screen size.

Level	Description	Example
Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badge, leaderboard, level
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraint, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyze a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	MDA; challenge, fantasy, curiosity; game design atoms; CEGE
Game design methods	Game design-specific practices and processes	Playtesting, playcentric design, value conscious game design

Table 1 - Levels of game design elements. (Deterding, et al., 2011)

Game elements can be implemented through game mechanics which according to (Bunchball, Inc., 2010) are tools, techniques, and widgets that are used as building blocks for gamifying a website or application, (Zichermann & Cunningham, 2011) say that is actually game mechanics what makes an application fun, and not the theme itself. They give examples of some not so fun activities like changing a baby's dirty diaper or planting crops are part of the most successful games in the past decade, e.g. planting crops (*FarmVille*) and diapering a baby (*DiaperDash*). For the game mechanics to be meaningful, the optimal scenario is when they match human desires, see figure 5.

Figure 5 - Interaction of basic human desires and game play. The green dots signify the primary desire a particular game mechanic fulfills, blue dots show the other areas that it affects. (Bunchball, Inc., 2010)

Since players of our application CampusMapperGamified are basically the students of the University of Münster, and based on what motivates a player to play (Zichermann & Cunningham, 2011) and (Bunchball, Inc., 2010), we decide to implement three game elements: Competition, Reward and Achievement, with special emphasis in competition. To materialize these three game elements, the game mechanics are: leaderboard, where all players are ranked according to their total score; score, that increases with every mapping action of the player; and a conquest map where the city of Münster is showed with a flag that can be of three different colors on the centroid of the buildings of the University of Münster, screenshots in chapter 5. These game mechanics are framed by the following rules:

1. The player has to enter data about the floorplan in *CampusMapperGamified* application; this data can be a corridor, room, stairs, elevator, entrance or door. For every piece of information will be a reward.

2. Any player can continue the mapping made by another user in a specific floor or start mapping a floorplan from scratch. The last data upload will overwrite the previous one, but the player who uploaded the previous version won't lose any score.

3. The player who gets more points per building is the user who owns that building.

4. The players will appear in the leaderboard in descendent order according to their total score, which is the sum of all score they have in one or more buildings.

GAME GOAL: Virtually conquer as many buildings as possible.

For the rule number one, there will be immediate reward given in points:

- 20 for a door.
- 20 for a room.
- 50 for a corridor.
- 80 for stairs.
- 80 for elevator.
- 100 points for an entrance.

The user who has more points per building, will virtually own the building and this is shown on a map of the city of Münster by using flags of different colors, so the user can see its own buildings, the ones that are still free and the ones belonging to other

competitors (see figure 6). Once the information is updated for any building, previous information is not available anymore, so the user, who got his information updated, will continue playing on the information provided by other players or start a new floorplan project.

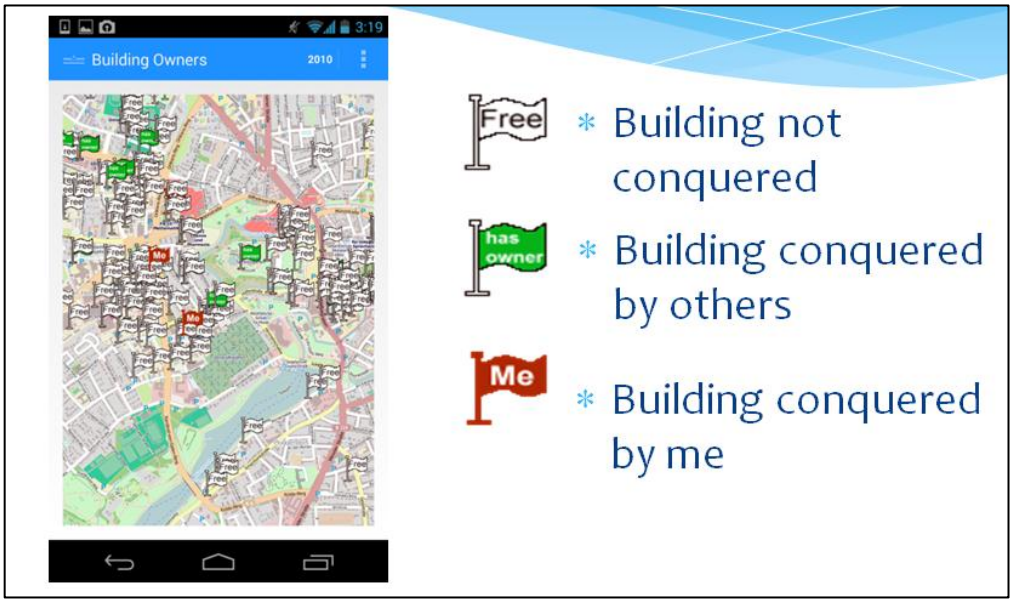

Figure 6 - Final goal of the game.

Before to start the implementation, a mockup prototype was tested for the gamification of *CampusMapper* application; we selected a heterogeneous target group of five students from the Institute for Geoinformatics of the University of Münster and explained to them a mockup sketch (see figure 7) built in a trial version of the *Balsamiq* Web tool (http://balsamiq.com/). The meeting lasted thirty minutes and was carried out as a semi-structured interview where the prototype was first explained to the audience and then a small discussion took place; all the comments provided by the users were recorded and here transcribed the most relevant ideas. After the group interview there was an individual interview where each participant was presented an interactive prototype on a smartphone and asked to use it, then we asked some questions that were recorded as well. With the interview, we basically try to figure out the first impression of the users with the graphic interface, also, some specific inquiries about the game mechanics and layout design were asked to the group.

The target group was integrated with five people, three male and two females, the age was between 23 to 34 years old. The main comments and observations from the interview were as follows:

The participants at the beginning were very curious about the functionality of CampusMapper app, questions like: "*how to draw a room?*", "*do you have to go physically to the place to map it?*". Then ideas as they would like to have two options available, individual and team approach, actually some of them said that actually they prefer to play only in teams, and if the team members and opposite teams are people they know in real life it would be much more interesting. All the participants agreed that the use of points, badges, leaderboards and maps makes the application more interesting and encourage them to give it a try. When asked about the position of the buttons the majority said they prefer to have a bar menu at the top. Then they were asked to give general comments and here are some of them:

"An introduction is important; it gives motivation for users because they will know what is behind it". Arturo, 34

"If you have something in common…. people competing in teams against other teams will make people more enthusiastic about this". Ami, 29

"Application games…. for me is one of the best ways to do try something…." Alex, 23

Figure 7 - CampusMapperGamified prototypes.

5 IMPLEMENTATION

In the field of mobile applications, we have two options for software development, it can be done either by native code or web code, each one of these approaches has its advantages and disadvantages, (Charland & Leroux, 2011) made a comparison of the user-experience between these two lines of implementation, although this study was made 3 years ago and these days we have more advanced technology both mobile devices and software developing tools, the main remarks are still completely valid. Native platform has wonderful abstractions for user-interface development; web platform is more limited in resources for user-interface; about the cost of developing, native code is more expensive than web code due to vast number of mobile devices models each one with different software platforms and versions (see table 2), this makes development and maintenance much more complicated and expensive. The key difference is in the performance, execution time is a huge consideration in the mobile world and impacts directly in the performance, the more there is to interpret, the longer the execution time, in this case native code has less to interpret, thus native platform has better performance than web platform.

Required skill sets for nine mobile OSs.

Mobile OS Type	Skill Set Required
Apple iOS	C, Objective C
Google Android	Java (Harmony flavored, Dalvik VM)
RIM BlackBerry	Java (J2ME flavored)
Symbian	C, C++, Python, HTML/CSS/JS
Windows Mobile	.NET
Window 7 Phone	.NET
HP Palm webOS	HTML/CSS/JS
MeeGo	C, C++, HTML/CSS/JS
Samsung bada	C++

Table 2 - Mobile OS and programming skills required. (Charland & Leroux, 2011)

In the study made by (Jacob & Coelho, 2011) they define a location based as a game that uses the player's physical location as input for access to specific location information such as maps, weather, or location-based services; although our *CampusMapperGamified* does not use the location of the user, it takes real geographic coordinates from OSM maps service, these coordinates plus the coordinates of the building centroids can be related with building elements mapped through its mobile device screen coordinates. (Jacob & Coelho, 2011) defines that one of the issues in

mobile location based game is due to hardware limitations such the device's usual low processing capabilities, small storage capacity, and small screen size.

The implementation of the new version was made following the same standards and technology used in the original version of *CampusMapper*, this new version is called *CampusMapperGamified* and was developed in java (https://www.java.com/en/) version 1.7 by using Android Developing Tools (ADT) for Eclipse (http://developer.android.com/tools/index.html) version 22.0.1. The application is connected to an open linked database (http://lodum.de/) that uses SPARQL as query language. The debugging was done in a LG Nexus 4 smartphone with Android 4.3. The application is supported by android mobile devices version 2.3.3 and above. A schema of the app architecture can be seen in figure 8. The source code of *CampusMapperGamified*, that is one of the contributions of this project, can be found and downloaded from here: (https://github.com/mijail79/CampusMapperGamified.git). The installer *.apk* version here: (https://www.dropbox.com/s/66cbkqki3p519c4/CampusMapperGamified.apk)

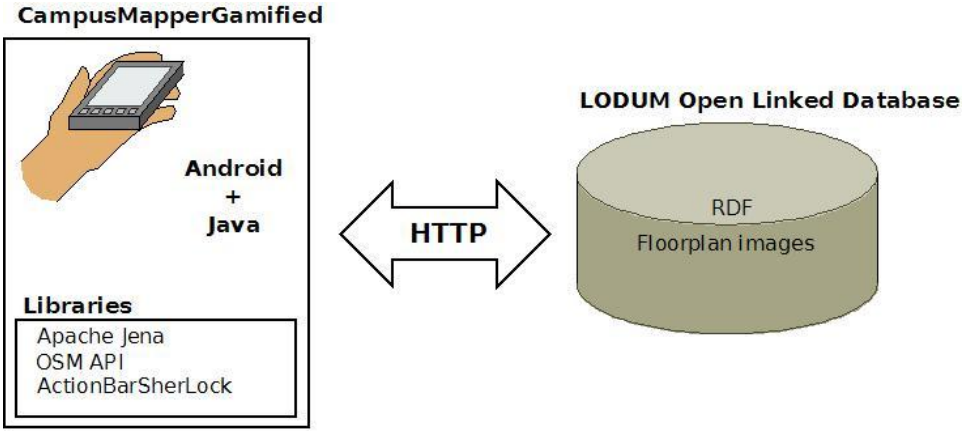

Figure 7 - CampusMapperGamified architecture.

Basically *CampusMapperGamified* has these new features comparing with its predecessor *CampusMapper* (figures 9, 10, 11, 12):

- Translated to English.
- User registration process.
- Score per every new element mapped.
- List of player ranked according to score from the highest to lowest.
- Flag icons to indicate ownership of a building.
- Conquest map.

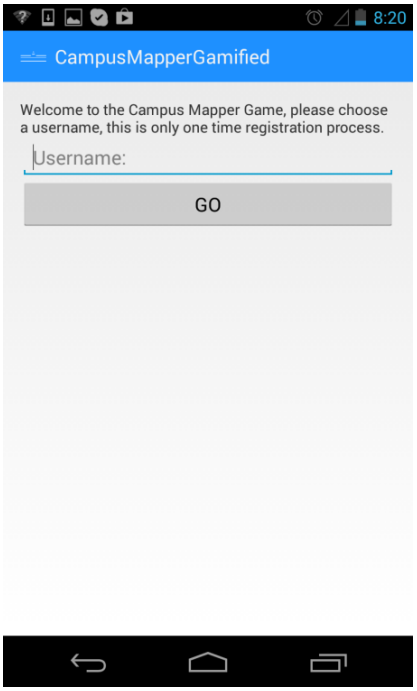

Figure 8 - User registration

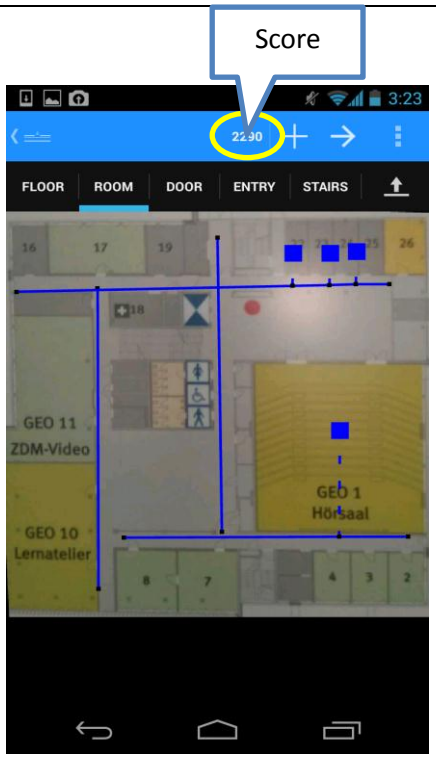

Figure 9 - Score and mapping

Figure 10 - Conquest map

Figure 11 - Leaderboard of players

6 EVALUATION

Once *CampusMapperGamified* was finished, the next step was the evaluation; the experiment has as its main purpose to determine if the new implemented game mechanics (leaderboard, scoring, and map of virtual conquests) present in *CampusMapperGamified* actually generate more enthusiasm and better acceptance than its previous version *CampusMapper* that has not implemented those game mechanics. Besides the comparison between both applications, individual ranking of each one of the game mechanics is also evaluated which of them has the higher impact on users. In this chapter and the next one the users are called participants.

6.1. EXPERIMENT

The environment where this experiment takes place is in the building of the Institute for Geoinformatics and the main library located in the city center of Münster. The participants were tested one by one or maximum in pairs and the whole experiment took about 20-30 minutes. The participants were recruited randomly just approaching them at the hall or at the end of some lectures and by word of mouth just ask for a 20 minutes experiment. The experiment used within subject design with each participant assigned two tasks in a counterbalanced order; one task was to try the gamified version and the other one was to try non-gamified version.

A total of 28 volunteer participants (14 women and 14 men), students of the University of Münster, were chosen to try two versions of CampusMapper app, gamified and not gamified one. Thus 14 users started using the non-gamified app and then the gamified one. The other 14 users did it the other way around; they began with the gamified application.

We want to measure enjoyment and preference between two versions of the app. For that purpose two questionnaires (see appendix 3 and 4) were handed out, one with questions about the subject's background and the other one about their opinion about the applications they tested. The second questionnaire has 9 questions with 5 of them with possible answers in intervals of 5 levels being 1 totally negative and 5 totally positive answer. Besides the questionnaires there were other apparatus used in the experiment: mobiles smartphones (HTC android 2.3.3 and Nexus 4 android 4.3) with internet connection and a floorplan picture available either in the memory of the device or on physically in the building, so participants could take a photo of it.

Participants were given first a legal (see appendix 2) form asking their consent to use the data and then a questionnaire about their background related with gamified apps, the information provided is completely anonymous and confidential. Once the first questionnaire is finished a smartphone with both versions of CampusMapper app was

handed out and asked to map any of the building stores for around three to five minutes and then we switched the app and asked the participant to repeat the mapping tasks over the same building floorplan used in the first try for around the same time. The alternation was applied between gamified and non-gamified app for every user, it means that if the first participant started with gamified application and then non-gamified app, the second participant started the test with non-gamified app and so on. After the participant finishes the task given with the apps, a second questionnaire was handed out to evaluate both apps and the impact of having gamified elements. Participants could ask any questions at any time during the study, either working with the apps or during the questionnaires. A detailed procedure step by step is specified in appendix 1.

Since it was the first experience for the participants with *CampusMapper and CampusMapperGamified*, they were guided in the interaction with the app during the experiment (see figure 13).

The order of activities were different in both applications, in non-gamified applications at the beginning participants were asked to select the building where they were are at the moment of the experiment and take a picture of the floor plan of their choice, then do mapping tasks for around 3 to 5 minutes. Finally, they uploaded the information and return the mobile device to the investigator. On the other hand, gamified version participant first were asked to take a look to the score, the leaderboard and to the conquest map before starting the mapping tasks. Then they were asked to perform the same activities specified for the non-gamified app, and at the end, asked again to take a look to the leaderboard and verify if they have gotten a better rank in the list of players.

Figure 12 - Giving instructions about the use of the app.

6.2. ANALYSIS

As mentioned before, questionnaires were the main tool to evaluate participants, by collecting their opinion about enjoyment in both applications; similar studies where questionnaires were applied have been carried out to measure the enjoyment in e-learning games (Fu, et al., 2009). In order to evaluate the data of our study, first we go through and analysis of totals summarized in a graph. Second we decided between the most common approaches are the *descriptive statistics* and *inferential statistics*, the first one contemplates, among other resources, a plot of histogram and, of course, observations derived from it, but since we have only 28 participants, in (Field & Hole, 2003) is suggested that we can't get a good idea of the distribution from less than 30 observations. Therefore the inferential statistics seems to be more appropriate to our analysis, they tell when the experimental hypothesis is likely to be true (Field & Hole, 2003). A common use of inferential statistics is parametric statistics, which work on arithmetic mean and so data must be measured at an interval or ratio level.

Among the inferential statistical methods the one that best fits our requirements is the *t*-Test which is used in the simplest experimental situation: two groups to be compared. In our case we have 28 participants; we can arrange the participants as 14 women and 14 men and, on the other side as well as 14 who began with gamified version and 14 who began with non-gamified version. The t-test is performed between two variables that the subjects contributed through the questionnaires (see appendix 4), these variables are questions related to the preference and enjoyability of the applications, more detail in the next chapter. In summary the methods used to perform analysis are basically twofold: summarized totals showed in graphs; and inferential analysis, specifically a *t*-test. Both analyses are carried out in Microsoft Excel.

7 RESULTS

This chapter analyses the answers obtained in the questionnaires, which gives us an idea of the users subjective opinion, the one about the background and the second one about the apps evaluation itself; also it provides personal observations from the investigator point of view about the participant's interaction with both applications. The subjects were grouped according to their gender, age and background in the use of gamified applications. Then the analysis is carried out in two ways: by presenting summarized data in graphs and by performing a *t*-test between two sets of variables: the first two are the questions about encouragement and conquest map and the next two the questions about fun and conquest map. Besides the *t*-test groups are also divided by gender, 14 male and 14 female are evaluated with the same condition. As mentioned in the previous chapter the experiment was carried out under the within subject approach and a counterbalanced order between the two options, gamified and non-gamified application.

Next comes the analysis of four questions and game mechanics from the questionnaire that are aimed to identify the first impression of participants regarding to the enjoyability and preference of applications tested. The results are divided by gender: 14 men and 14, and by the participant's background related to computer games.

a. Which mobile app would you use in case you want to perform indoor mapping tasks?

On the figure 14 we can see that the preference of men for the gamified version is slightly higher from women but still both of them answered that they preferred gamified version over the non-gamified one. Alternatively, in figure 15 it is interesting to read that participants who play computer games more often are more likely to prefer gamified version, we can see in the first set of columns (do not play) there is no difference in preference between apps.

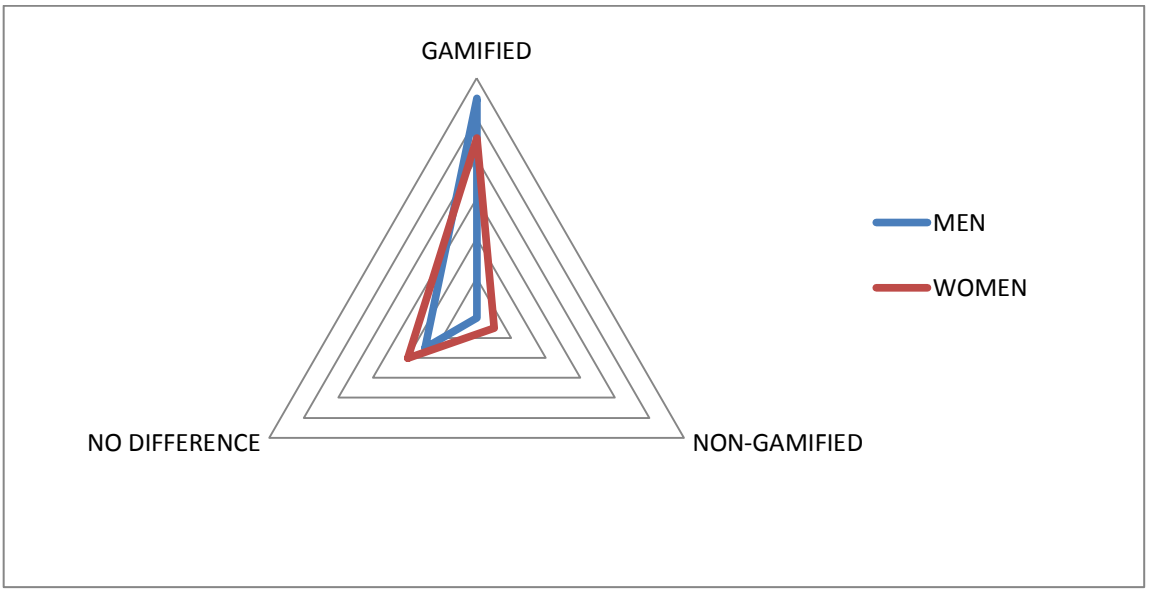

Figure 13 - Preferred app for indoor mapping by gender.

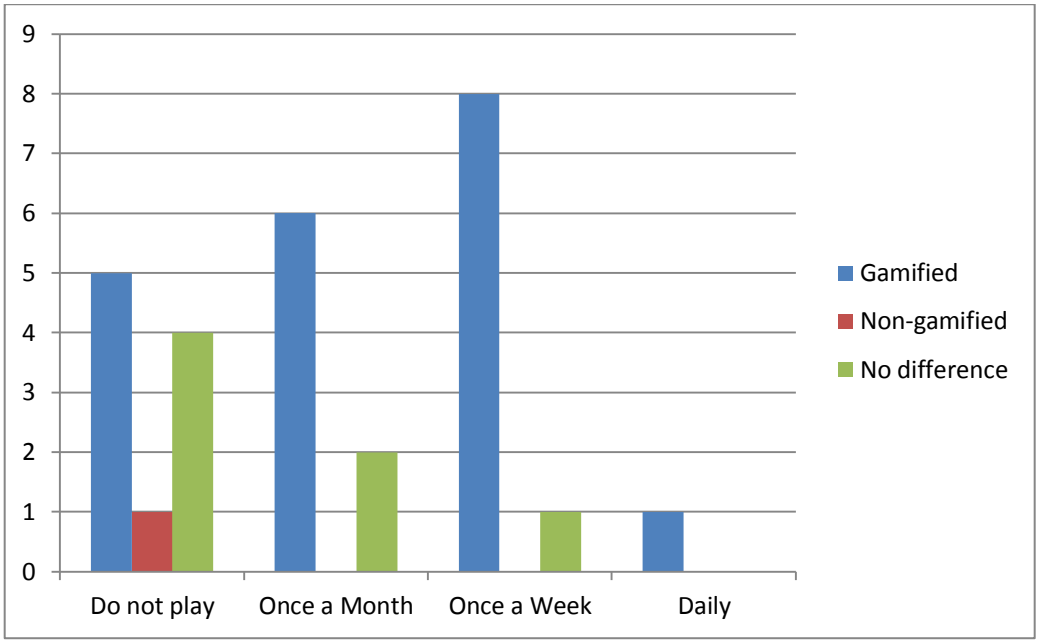

Figure 14 - Preferred app for indoor mapping by participant's experience with computer games.

b. Did you feel encouraged to improve you score and compete against other users when you used the gamified version by mapping more indoor elements?

In this question we can observe that men and women answered almost the same way (see figure 16), the highest values are "partially yes" and "absolutely yes" which means a strong but subjective answer that participants felt encourage to improve their score.

On figure 17 we compare the answers with participant's profile on their experience with computer games, we can see that the most of participants are in the range of playing computer games from once a week to once a month and those participants answered "likely yes" to the question about encouragement to improve score.

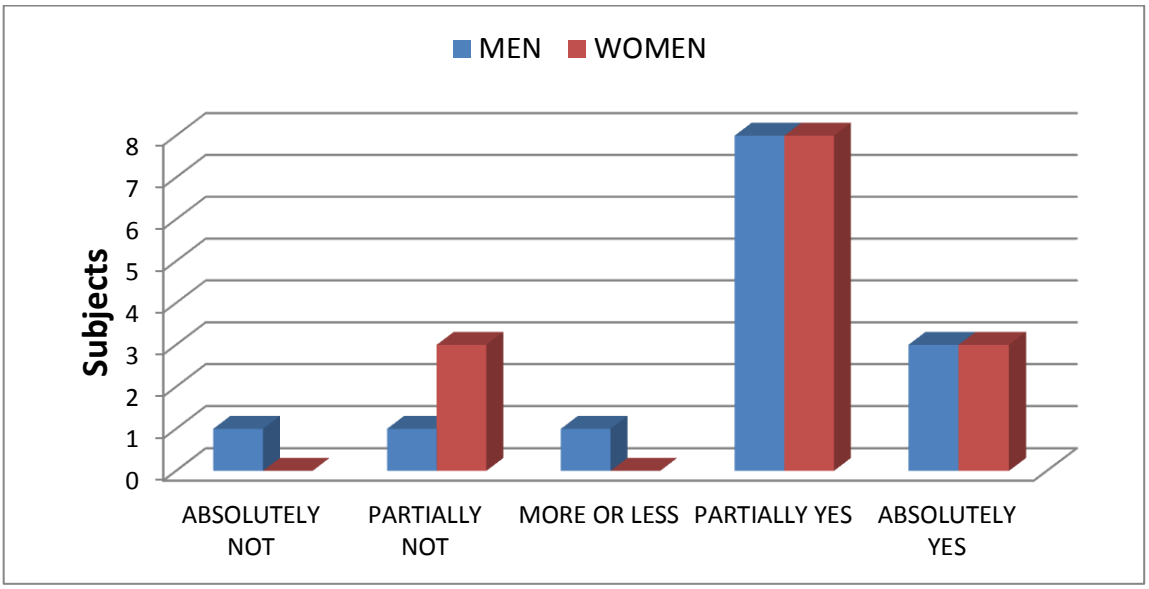

Figure 15 - Encouraged to improve score.

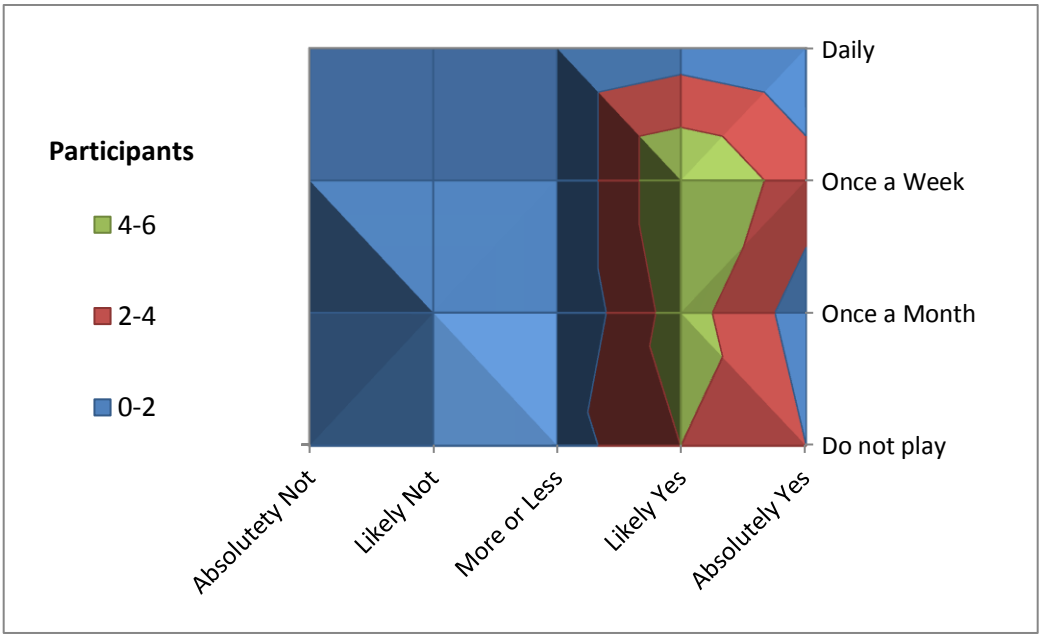

Figure 16 - Encouraging related to the user's profile in other computer games.

c. Did you have fun when used gamified version?

This question has less strong positive answers than the previous one but still there is a tendency for “partially yes” and “absolutely yes” answers, we can observe it at figure 18. On figure 19, about the perception of “fun” according to participant’s experience with computer games, there is not a clear tendency, seems like the experience with computer games was not a factor of influence for this question.

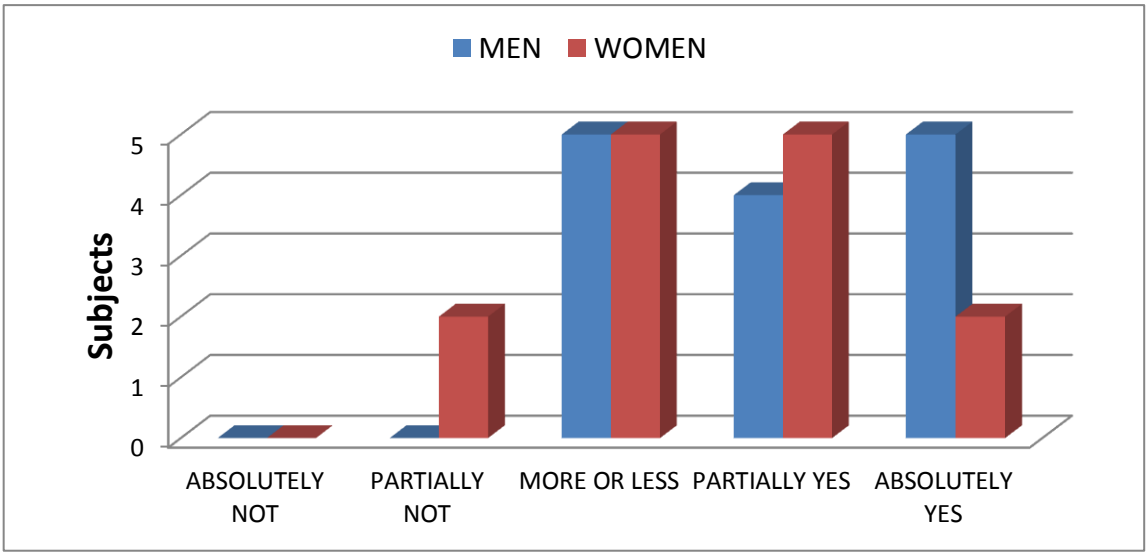

Figure 17 - Fun when used gamified version.

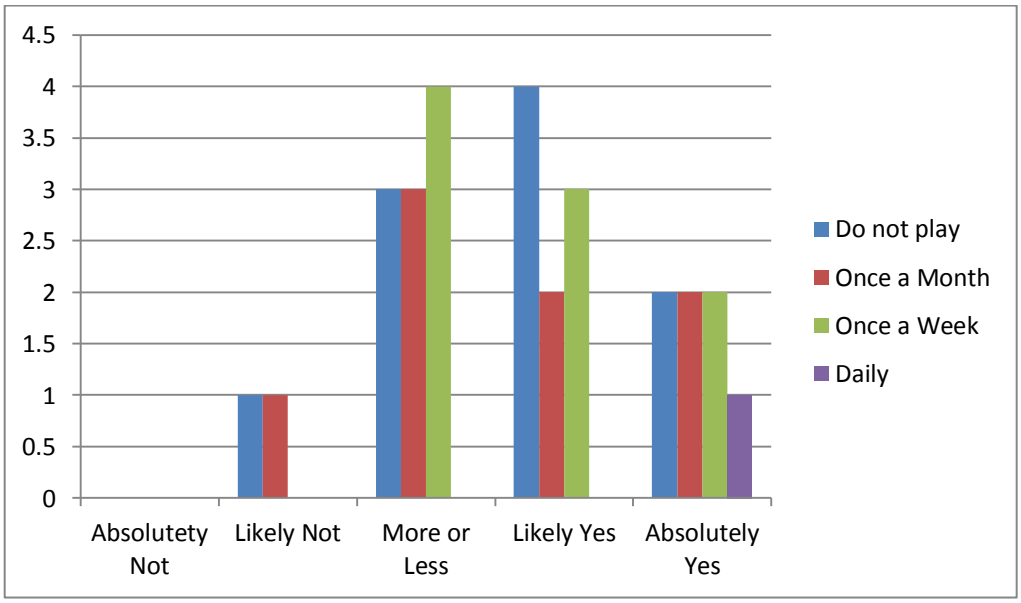

Figure 18 - Fun with gamified application based on user’s experience in games.

d. Do you think it would be more fun to use the gamified version app in teams?

This question is absolutely subjective and tries to get just the pure opinion or the user; even though gamified application has not any option to play in teams the participants may have a notion or preference about this approach. Figure 20 indicates that men answers were positive to suggest that it would be fun to play in teams.

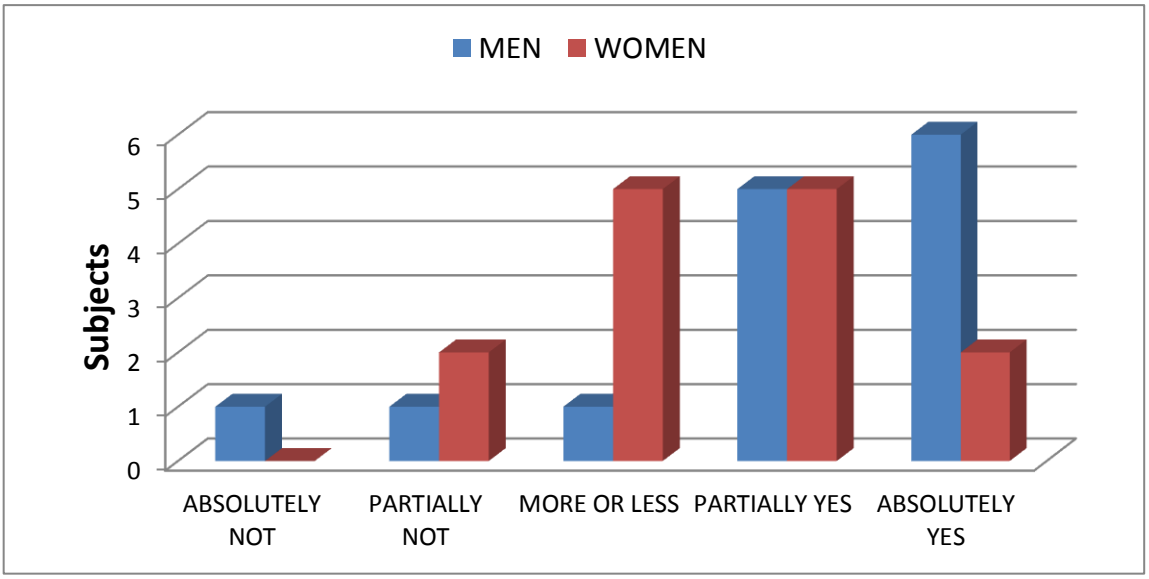

Figure 19 - Play in teams.

The three game elements developed for the gamified version (score, leaderboard and conquest map) were evaluated individually (please see question 4 in appendix 4):

Score	I did not liked ❍ ❍ ❍ ❍ ❍ Totally enjoyed
Leaderboard	I did not liked ❍ ❍ ❍ ❍ ❍ Totally enjoyed
Ownership map	I did not liked ❍ ❍ ❍ ❍ ❍ Totally enjoyed

From the figure 21 we can observe that the three game mechanics were rated in a positive way and the one that users liked the most was the conquest map as well as we also can observe that men liked the game mechanics more than women.

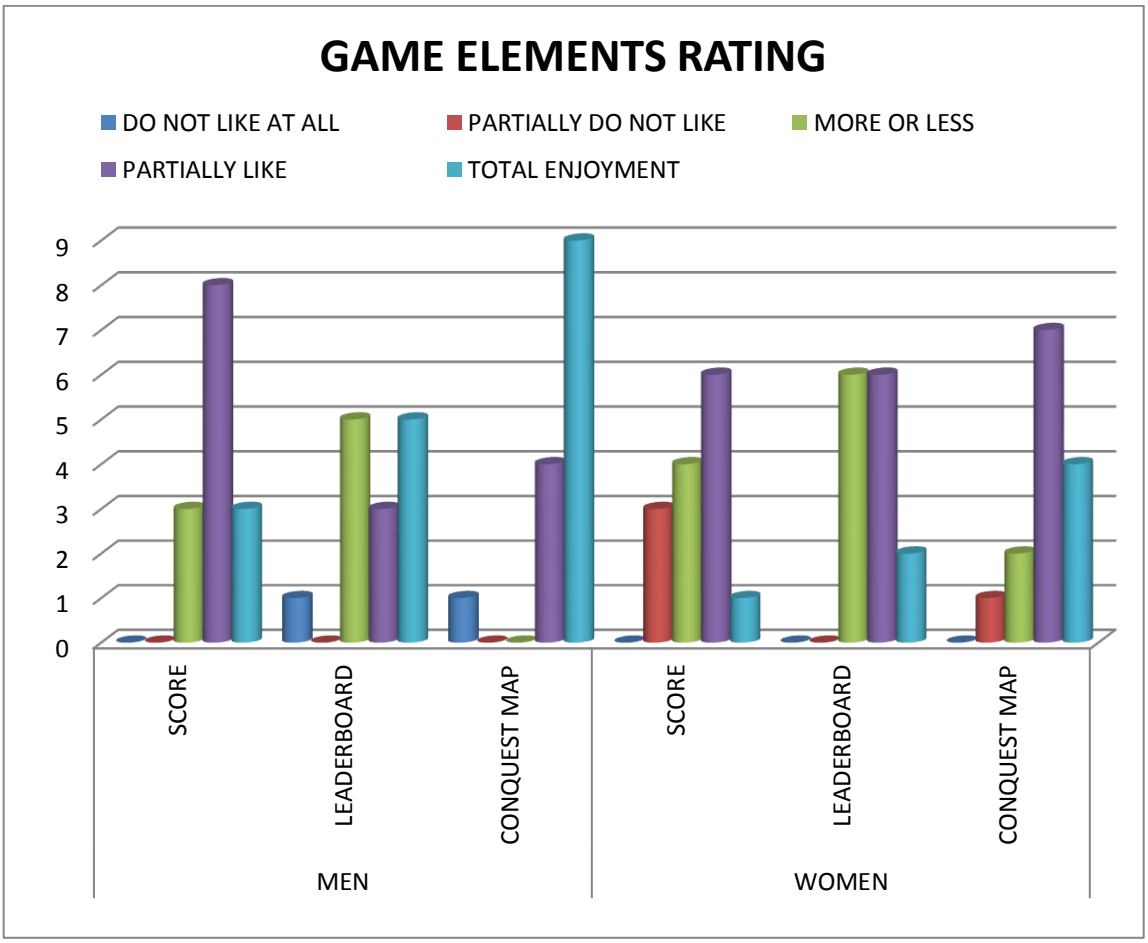

Figure 20 - Game elements rating

After examining these five charts we can clearly see that the most of answers from both men and women are for the “Partially yes” and “Absolutely Yes”. It may suggest that the gamified version was the favorite one from a first impression of participants; even when the app was not designed to play in teams, the most of subjects answered positively when they were asked about possible play in teams scenario, so the team approach may be consider for future research.

We also can observe a small difference between the answers from men and women, generally speaking the analysis suggest that men are slightly more enthusiastic with gamified version than women.

By applying the correlation function in Excel between game mechanics and questions 5 and 6 of questionnaire 2 (see appendix 4) we can observe that correlation index (r), that is calculated in Excel and has values from 0 to 1, where 1 means a perfect correlation and 0 no correlation at all. For our study the values that are significant for us are the ones where $r > 0.5$, in this case participants who answered felt encouraged also liked the conquest map and participants who said to had fun with gamified version

also liked leaderboard and conquest map as game mechanics. On the other hand there is a correlation between the game mechanics leaderboard and conquest map, it means that people who liked the option of leaderboard also like the conquest map. Please see Table 3.

	Encouraging	*Fun*	*Score*	*Leaderboard*	*Conquest Map*
Encouraging	1				
Fun	0.467765648	1			
Score	0.163833017	0.404689	1		
Leaderboard	0.484766798	0.505585	0.122047	1	
Conquest map	0.568544965	0.501564	0.169507	0.5582973	1

Table 3 - Correlation index

In the next two tables we have the results of a *t*-test performed in Microsoft Excel with the data obtained from the questionnaire 2 (see appendix 4) by comparing question 5 and 6 with the acceptance of the highest ranked game mechanic, the conquest map. Since the data evaluated is subjective our reading are based only on the Pearson correlation and the *t* value. Table 4 and 5 we have a group of 28 subjects that went through two different questions with the same interval level (from 1 to 5, being 1 absolutely negative and 5 absolutely positive). In the first case there is a substantial Pearson correlation (r = 0.568) indicating that participants who suggested to felt encourage to increase the score also like the conquest map game mechanic, and a value of *t=-2.36* gives us an idea that the effect is statistically significant and the minus sign (-) indicates that the mean value of the conquest map question is bigger than the mean value in question 5. We can do the same reading for table 3 between the question 6 about fun with gamified application and conquest map where correlation r = 0.501 and t=-2.55 due to the similar values. There are more questions in the questionnaire that we can analyze by means of *t*-test but actually what we want want to show through this test is a relation between what the participants said in terms of enjoyability and the game mechanics.

	Encouraging	*Conquest Map*
Mean	3.785714286	4.214285714
Variance	1.137566138	0.989417989
Observations	28	28
Pearson Correlation	0.568544965	
Hypothesized Mean Difference	0	
df	27	
t Stat	-2.363515791	
P(T<=t) one-tail	0.012778511	
t Critical one-tail	1.703288446	
P(T<=t) two-tail	0.025557023	
t Critical two-tail	2.051830516	

Table 4 - t-test between question 5 and conquest map

	Fun	*Conquest Map*
Mean	3.75	4.214285714
Variance	0.861111111	0.989417989
Observations	28	28
Pearson Correlation	0.501564455	
Hypothesized Mean Difference	0	
df	27	
t Stat	-2.55497495	
P(T<=t) one-tail	0.008285228	
t Critical one-tail	1.703288446	
P(T<=t) two-tail	0.016570455	
t Critical two-tail	2.051830516	

Table 5 - t-test between question 6 and conquest map

PARTICIPANTS SUGGESTIONS:

The last questions of the questionnaire that participants filled up after testing the applications asked them to give further comments, this is an open question and they could write anything they wanted. The annotations were regarding either to usability and to gamification; in total we receive 14 comments. Here we summarized some of them:

Regarding to the usability three participants expressed that drawing the indoor elements were not so friendly and another user wrote that would be a good idea include a tutorial, others said that need more time to understand the functionality and

did not like “+” and finally navigation between interfaces should be improved. On the other hand, comments related to gamification a couple of participants suggested a more animated interface in terms of graphical design, three participants advised they would like to have more competition and one of them actually recommended to share leaderboard results in social media, one participant told us about to receive bonus score when giving more semantic details about indoor elements, three participants said that gamification was not disturbing with mapping tasks and actually was a good experience.

PERSONAL OBSERVATIONS:

During the experiment the investigator was close to the participants and was able to observe their behavior. In general speaking the most of participants were curious about what it is the purpose of the application, as well as when they did their first draw on the screen and when they saw the map of city of Münster with the flags meaning the virtual ownership; others were just indifferent with the experiment and seems like they wanted to finish and leave as soon as possible. Just a few participants give the impression to be excited when they tried the gamified application and checked out the game mechanics.

8 DISCUSSION

Collecting indoor spatial data it is yet a big challenge for science and industry for the reasons explained in chapter 1. The use of volunteered geographic information is the actual tendency to collect indoor data based on the principle that daily users are who should contribute with this information. *CampusMapper* came as an attempt to provide a tool for users to perform indoor mapping but then another question comes up, how to motivate the users? Among other methods, gamification seems to be a promising approach to produce that motivation. *CampusMapperGamified* mobile application is an attempt to prove that gamification can help to engage users to perform indoor mapping tasks and this study explores the degree of acceptance and preference of this line. Even though the results are not objective, during the experiment users seemed to be curious about the version with game mechanics.

In this section we are discussing the main issues and findings in this project, although the results suggest that gamification actually motivates users to perform indoor mapping more that if they would use the non-gamified version, the main problem is that the results are not coming from objective datasets but subjective ones due to the methods of evaluation, while in related works as *Urbanopoly* (Celino, et al., 2012) or *CityExplorer* (Matyas, et al., 2008) were evaluated for around one month collecting data trough logs and by the application data itself. A similar method of evaluation was planned to be applied in this thesis project and then by having two applications available into the wild, gamified and non-gamified one for anyone to download it and later analyze the data uploaded into the database as well as the logs capturing the user behavior. Nevertheless was not possible to reach a fully ideal scenario because of some limitations related with the original application, those limitations and problems are discussed in the next subsections.

8.1. THE APP - LIMITATIONS

Since the original version of *CampusMapper* was not part of this project, one of the challenges was to understand the code and structure of that version before to implement the new version *CampusMapperGamified*, during the implementation phase some bugs were detected in the original version and some of them still persist in the application, for that reason it is not a good idea to release it into the wild in platforms like GooglePlay because it is well known that if a user downloads a mobile applications and it crashes frequently the user will uninstall the app or just stop using it. Without having the application released was not possible to gather real spatial data and monitor the natural behavior of the users. Some of the bugs found are described in the following lines:

- After using the application for several times (4 or 5) and go through the whole process of taking a picture and then perform the mapping, the app crashes after the picture is taken, the reason for this bug in unknown but may be related with the management of the resources in the memory of the device.
- After create several projects with different smartphones models, some floorplans are not able to be open anymore from the list of “existing projects”, which would make loose what a user have been done.
- In some mobile devices like the HTC android 2.3.3 the option of “ENTRY” fails and makes the application to crash.
- When doing the cropping of the floorplan picture, if we take the vertex points to the limits of the smartphone screen and then tap “next” it crashes, see figure 22.

Figure 21 - Bug detected when cropping.

For the mobile application to work it must have an internet connection and a database (http://lodum.de/) available, from the database the application retrieves the list of buildings of the University of Münster and also stores all the mapping information as well as the scores that users obtain through game mechanics. Unfortunately, the database management and control was not responsibility of this project, the database was hosted by the Library of the University of Münster and during the development of *CampusMapperGamified* it crashed very often, several times during the week, which resulted in a delay of the development phase. Besides de availability, the data stored

was also incomplete. In the conquest map a flag is overlaid on the buildings centroid and this centroid data was not available for all the buildings.

During the experiment many users asked questions about the functionality and furthermore gave suggestions in the usability context (see previous chapter for specific user comments), even the most basic operation like a finger swipe to draw a corridor was not very intuitive for many participants and had to ask about it. Although we were evaluating gamification, it is possible that some users were slightly biased by the usability, we have no data to demonstrate it but we could notice that some users felt a little bit frustrated when they did not understand how to perform certain tasks, this perception of usability of the mapping itself could have impacted the perception on the game mechanics.

8.2. EVALUATION

The ideal scenario for the experiment is to have *CampusMapper* and *CampusMapperGamified* released into the wild and monitoring the use of them for around a month comparing the indoor spatial data collected by both applications and with logs in the database that let us to track the user's behavior, of course the option to study the user's actions is possible only in the gamified version due to this one requires a username at the first time the app is started and takes the email account from the smartphone registry, with the data of user's behavior would be feasible to collect objective data about preference for specific game mechanics, e.g. by knowing how many times the user visits the conquest map. This ideal scenario was not possible to achieve because the applications still have bugs, therefore is not possible to release them into the wild. The original application requires more work in order to fix all the bugs and implement logs that track the user's actions.

An alternative option, without releasing the applications, is to evaluate them for a longer period of time by giving to the participant a mission to map a particular floorplan or building, let's say for example one entire day where participant can map the Geoinformatics building at any time during the day and then all the actions are recorder in a local log file in the mobile device, the problem of this approach is that we need to find users with android devices version 2.3.3 or above, and of course as longer the experiment the more complicated is to recruit participants, as well as more difficult to convince them to install an application in their android devices since there are privacy issues, the gamified version require grant permissions to read the contact list to get the email address of the user.

Participants were recruited randomly by word of mouth in the building of Institute for Geoinformatics and in the main library by asking them to take part in a 20-30 minutes experiment. During the experiment participants had many questions about the functionality of the app, thus the investigator was close to them all the time giving instructions and answering all the doubts they may have. This guide was necessary

due to the short time for the experiment but on the other hand it may have influenced the natural behavior of the user with the app without any external help.

The data evaluated with questionnaires is a subjective opinion of participants, it is their first impression of the apps after use them for about 5 minutes each, even though we got positive results in the sense that participants tended to prefer gamified application we still do not know if they will really use the app voluntarily and if so, then the next inquiry is for how long they will be engaged with the app and with indoor spatial mapping tasks.

8.3. RESULTS

Since the results are subjective answers from participants turns out very difficult to answer to the research question stated in chapter 1: *Do the gamification elements in an indoor mapping application encourage users more to perform mapping tasks than if using an application without gamification approach?.* Nevertheless we still can say that our results suggest that users preferred the gamified application over the non-gamified one. The results also suggested that male liked the gamified app more than female. Besides the subjectivity or objectivity of the data, one of the limitations is also the number of participants, with only 28 subjects there are certain statistical analysis like descriptive statistics that are not significant because they require at least 30 participants (Field & Hole, 2003).

In the application *panOULU Conqueror* (Tiensyrjä, et al., 2010) that was evaluated with 96 participants they found that the perception of the user did not match with the log of the game, based on that experience we may expect that by having logs implemented in *CampusMapperGamified* the results could vary from what we got in the questionnaires. In *Urbanopoly* (Celino, et al., 2012) they used the ALP indicator (Von Ahn & Dabbish, 2008), described in further detail in subsection 2.5 to assess the user engagement that was 100 minutes in around a month. This could be the best way to get objective results for our application, with logs implemented and application released into the wild we can get the ALP indicator and from it calculate the “expected contribution” (Von Ahn & Dabbish, 2008) which finally will let us come up with a conclusion and projection of the impact of gamification to perform indoor mapping tasks.

8.4. INDOOR SPATIAL DATA

The main purpose of *CampusMapper* is to map indoor spatial data as accurate and reliable as possible, gamification is just a means of incentive to motivate users to keep collecting indoor spatial data from buildings. The data collected is semantic and geometric (e.g. "Point((33 167))" or "Line((402 164, 387 499))") with a reference system based on the internal coordinates of the mobile device’s screen; we can query the database here: http://data.uni-muenster.de:8080/openrdf-workbench/repositories/indoormapping/query. Please refer to some useful SPARQL

queries in appendix 7. More database queries are in the source code of the mobile application, a link to it can be found in chapter 5.

By looking at the data drawn (e.g. figure 10) we can infer that in general speaking the accuracy of the data mapped is acceptable, for example the corridors where no drawn over the rooms of the floorplan, in some cases when users made mistakes they immediately deleted the last action and repeated the drawn to make a more accurate one. Nevertheless there were some users that did not understand clearly the idea of how to map the building elements, e.g. they drew lines around the rooms and not as a corridors, so it suggest that some users did not actually understand that a line only represents a corridor and not a wall.

So far it was possible just to make a personal observation at the raw data, which in general terms seems to be acceptable, but in order to assess effectively the accuracy and reliability of the data we need to construct a 3D model with the data and then verify against official data, an interesting question is how to select the best data from all the inputs made by users? We should take into account that since the screen size varies from one device to another the reference systems are also slightly different from each other. As it is implemented now, any user is able to overwrite someone else's data per floorplan, so basically we trust the crowd. The problem is when the user creates a new floorplan project then in the database we have several mapped floorplans.

9 CONCLUSIONS

This project presents introductory insights to the combination of gamification and volunteered geographic information to collect indoor special data. There is still a long way to go in further research to really determine precisely the optimal game mechanics regarding the user type, the goal of the application and the technical limitations of mobile devices.

Results from the experiment carried out by comparing two applications, gamified and non-gamified, suggest a user preference to choose the gamified version after a short interaction with the app, of course still have not been demonstrated that game mechanics implemented in the gamified version actually engage and encourage people to perform indoor mapping tasks more than non-gamified version as well as we cannot say for how long this user's enthusiasm will last.

From the literature review we can tell that a satisfying cost-effective method to collect indoor spatial information is not found yet, nevertheless a strong trend is arising to the use of volunteered geographic information. Gamification has been used successfully in other software applications to collect spatial data as the ones stated in subsection 2.5, so we may say that in fact gamification could be an interesting strategy to motivate people to volunteer spatial indoor data, but it is still not clear which game mechanics are the most appropriate to develop, since it depends on some factors as the type of users and capabilities of electronic devices as smartphones.

9.1. FUTURE WORK

The very first action that should be taken if someone wants to extend this project is to implement logs that save the user's behavior in the database for further analysis and identification of the optimal game mechanics according to the user type and mobile platform.

Since participants expressed their interest for a gamification approach to be played in teams, it should be extended to implement game mechanics capable to support playing in teams.

One of the problems that face the crowdsourcing approach to collect indoor spatial data is that we may have many mapped floorplans from different users, then how to choose the best one? A possible solution is to implement reputation to users and then the data from users with higher reputation will prevail; this approach is used in other crowdsourcing projects like stackoverflow (www.stackoverflow.com).

Another strong suggestions made by users was the interaction with social media, in the sense of sharing their progress and results obtained through indoor mapping, this may

produce a bigger motivation in some users since it becomes more competitive as suggested in (Hamari et al., 2013).

The building's indoor spatial data collected through *CampusMapper* is stored in an open linked database as geometric entities like lines or points by taking the local coordinates of mobile device. As a further step in the use of that information is the 3D modeling of it, first by assessing its accuracy and reliability and then by applying that data for navigation or localization purposes.

In (Goodchild, 2010) the author takes a look into the future of GIS in the next 10 years, let's look at the main points and then contrast them with our project: a) he suggests that "it will be possible to know where everything is, at all times", b) "we are rapidly approaching a time when the average citizen is both a consumer and producer of geographic information", c) "numerous applications would follow from the development of a truly 3D GIS that was capable of handling the complex internal structures of mines, buildings, and retail complexes" and d) "Information would be acquired in vast quantities from…..humans themselves using their senses and intelligence to synthesize useful information". It has been passed four years already and seems that research is going towards those four points, even though there are many questions enclosed in those observations to the future, our approach of volunteered geographic information fits with the perspective described in the points b and d. Point a and c may fit as a next step once the data collected by CampusMapper is available. All of this makes us think that we are following the right path and contributing with a research of a cost-effective way to do indoor spatial mapping.

REFERENCES

1. Rosser, Julian, Jeremy Morley, and Mike Jackson. "Crowdsourcing Building Interior Models." *1 st AGILE PhD School* (2012): 118.

2. Goetz, Marcus, and Alexander Zipf. "Extending openStreetMap to indoor environments: bringing volunteered geographic information to the next level."*Rumor M, Zlatanova S, ledoux H (eds) Urban and regional data management, Udms Annual* (2011).

3. Goetz, M., and A. Zipf. "Mapping the Indoor World: Towards Crowdsourcing Geographic Information About Indoor Spaces." *GIM international* 26.3 (2012): 30-34.

4. Surowiecki, James. *The wisdom of crowds*. Random House Digital, Inc., 2005.

5. Goodchild, Michael F. "Citizens as sensors: the world of volunteered geography." *GeoJournal* 69.4 (2007): 211-221.

6. Cziksentmihalyi, Mihaly. *Flow*. HarperCollins, 1991.

7. Howe, Jeff. "The rise of crowdsourcing." *Wired magazine* 14.6 (2006): 1-4.

8. Von Ahn, Luis. "Games with a purpose." *Computer* 39.6 (2006): 92-94.

9. Mooney, Peter, and Padraig Corcoran. "Characteristics of heavily edited objects in OpenStreetMap." *Future Internet* 4.1 (2012): 285-305.

10. Goodchild, Michael F. "Twenty years of progress: GIScience in 2010." *Journal of Spatial Information Science* 1 (2013): 3-20.

11. Buecheler, Thierry, et al. "Crowdsourcing, Open Innovation and Collective Intelligence in the Scientific Method-A Research Agenda and Operational Framework." *ALIFE*. 2010.

12. www.foursquare.com, last revision 10-Feb-14.

13. Deterding, Sebastian, et al. "From game design elements to gamefulness: defining gamification." *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*. ACM, 2011.

14. Celino, Irene, et al. "Urbanopoly: Collection and Quality Assessment of Geo-spatial Linked Data via a Human Computation Game." *Finalist to the 10th Semantic Web Challenge* (2012).

15. Celino, Irene. "Geospatial Dataset Curation through a Location-based Game."(2013)

16. www.wikimapia.org, last revision 10-Feb-14

17. Alzantot, Moustafa, and Moustafa Youssef. "CrowdInside: automatic construction of indoor floorplans." *Proceedings of the 20th International Conference on Advances in Geographic Information Systems*. ACM, 2012.

18. Matyas, Sebastian, et al. "Designing location-based mobile games with a purpose: collecting geospatial data with CityExplorer." *Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology*. ACM, 2008.

19. Tiensyrjä, Juha, et al. "panOULU conqueror: pervasive location-aware multiplayer game for city-wide wireless network." *Proceedings of the 3rd International Conference on Fun and Games*. ACM, 2010.

20. www.wikipedia.org, last revision 10-Feb-14

21. Ferrara, John. *Playful Design*. O'Reilly, 2012.

22. Hamari, Juho, Jonna Koivisto, and Harri Sarsa. "Does Gamification Work?—A Literature Review of Empirical Studies on Gamification." *Proceedings of the 47th Hawaii International Conference on System Sciences. HICSS*. 2014.

23. www.openstreetmap.org, last revision 10-feb-14

24. Koster, Raph. *Theory of fun for game design*. O'Reilly Media, Inc., 2010.

25. Huotari, Kai, and Juho Hamari. "Defining gamification: a service marketing perspective." *Proceeding of the 16th International Academic MindTrek Conference*. ACM, 2012.

26. http://fold.it/portal/, last revised on 10-Feb-2014

27. Michael, David R., and Sandra L. Chen. *Serious games: Games that educate, train, and inform*. Muska & Lipman/Premier-Trade, 2005.

28. http://lodum.de/, last revised on 11-Feb-14

29. Li, Ki-Joune. "Indoor space: A new notion of space." *Web and wireless geographical information systems*. Springer Berlin Heidelberg, 2008. 1-3.

30. Jacob, João Tiago Pinheiro Neto, and António Fernando Coelho. "Issues in the development of location-based games." *International Journal of Computer Games Technology* 2011 (2011).

31. Henry, Peter, et al. "RGB-D mapping: Using Kinect-style depth cameras for dense 3D modeling of indoor environments." *The International Journal of Robotics Research* 31.5 (2012): 647-663.

32. Thrun, Sebastian. "Robotic mapping: A survey." *Exploring artificial intelligence in the new millennium* (2002): 1-35.

33. Hähnel, Dirk, Wolfram Burgard, and Sebastian Thrun. "Learning compact 3D models of indoor and outdoor environments with a mobile robot." *Robotics and Autonomous Systems* 44.1 (2003): 15-27.

34. Li, JL Ki-Joune, and Jiyeong Lee. "Indoor spatial awareness initiative and standard for indoor spatial data." *Proceedings of IROS 2010 Workshop on Standardization for Service Robot*. Vol. 18. 2010.

35. http://www.citygml.org/, revised on 11-Feb-14

36. Field, Andy P., and Graham Hole. *How to design and report experiments*. Los Angeles, CA: Sage, 2003.

37. http://balsamiq.com/ Last revised on 14-10-2013

38. White Paper - Gamification 101: An Introduction to the Use of Game Dynamics to Influence Behavior. Bunchball-2010 (http://www.bunchball.com/gamification101)

39. Deterding, Sebastian. "Meaningful play: Getting gamification right." *Google Tech Talk* (2011).

40. Zhang, Dongsong, and Boonlit Adipat. "Challenges, methodologies, and issues in the usability testing of mobile applications." *International Journal of Human-Computer Interaction* 18.3 (2005): 293-308.

41. Sweetser, Penelope, and Peta Wyeth. "GameFlow: a model for evaluating player enjoyment in games." *Computers in Entertainment (CIE)* 3.3 (2005): 3-3.

42. Bell, Marek, et al. "Interweaving mobile games with everyday life." *Proceedings of the SIGCHI conference on Human Factors in computing systems*. ACM, 2006.

43. Kallio, Titti, and A. Kaikkonen. "Usability testing of mobile applications: A comparison between laboratory and field testing." *Journal of Usability studies*1.4-16 (2005): 23-28.

44. Von Ahn, Luis, and Laura Dabbish. "Designing games with a purpose."*Communications of the ACM* 51.8 (2008): 58-67.

45. Fu, Fong-Ling, Rong-Chang Su, and Sheng-Chin Yu. "EGameFlow: A scale to measure learners' enjoyment of e-learning games." *Computers & Education*52.1 (2009): 101-112.

46. Zichermann, Gabe, and Christopher Cunningham. *Gamification by design: Implementing game mechanics in web and mobile apps*. " O'Reilly Media, Inc.", 2011.

47. Charland, Andre, and Brian Leroux. "Mobile application development: web vs. native." *Communications of the ACM* 54.5 (2011): 49-53.

48. http://wiki.openstreetmap.org/wiki/IndoorOSM, last revised on 13-Feb-2014.

49. Talen, Emily. "Constructing neighborhoods from the bottom up: the case for resident-generated GIS." *Environment and Planning B* 26 (1999): 533-554.

50. Brathwaite, B., and Schreiber, I. Challenges for Game Designers. Charles River Media, Boston, Ma, 2008.

51. Nicholson, Scott. "A user-centered theoretical framework for meaningful gamification." *Proceedings GLS* 8 (2012).

52. Reeves, Byron, and J. Leighton Read. *Total engagement: How games and virtual worlds are changing the way people work and businesses compete*. Harvard Business Press, 2009.

53. Hamari, Juho, and Jonna Koivisto. "Social motivations to use gamification: an empirical study of gamifying exercise." *Proc. of ECIS*. 2013.

APPENDICES

APPENDIX 1: Investigator's procedure.

1. Make sure there are two smartphones android version 2.3.3 or above with both applications installed (gamified and not gamified), with Internet signal available and enough battery.
2. At the first time the application is launched after installation, it asks a username, the investigator must provide any nick name.
3. Pick up the participants (one or two at a time) for 20-30 minutes of their time.
4. Read out general instructions and the rights of the participants.
5. Hand out the legal form for consent.
6. Hand out initial questionnaire (5 minutes), about participant's background.
7. Hand out the smartphone with the CampusMapper/CampusMapperGamified app open, this will be alternately, it means first a participant given a smartphone will start with CampusMapper app and then with CampusMapperGamified. The next participant will start with CampusMapperGamified and so on.
    a. Explain the functionality of the app. (1 minute)
    b. Ask the subjects to map any of the floorplans available in the building where the experiment is taking place, about 5 minutes each.
    c. Make sure the participants upload the data they mapped and in the case of the gamified app, make sure they took a look of the gaming elements (score, leader board, conquest map).
    d. Repeat the activities from b to c with the other app with the same subject.
8. Hand out second questionnaire. (5 minutes)

APPENDIX 2: Legal form to get participants consent.

Participant Number _____

Informed Consent Form for Experimental Research - Institute for Geoinformatics, University of Muenster

Project: Game elements to encourage the crowd to perform indoor mapping tasks.

Investigator: Mijail Naranjo
Address: IFGI, Heisenbergstraße 2, Münster
Email 1: m_nara01@uni-muenster.de
Email 2: mijail_naranjo@hotmail.com

1. **Purpose:** Study the field of crowdsourcing and gamification. The main goal is come up with an answer whether the game elements in mobile applications can encourage users to perform indoor mapping tasks. This study is part of a master thesis project.

2. **Procedures to be followed**: In the experiment you will be given first a questionnaire with questions about your background related with mobile gamified apps. Once the first questionnaire is finished, a smartphone with two versions of an app for indoor mapping purposes will be hand out and you will be asked to interact with them, you can ask any question about the app functionality during the experiment. Then a second questionnaire is hand out to evaluate the apps.

3. **Discomforts and Risks**: There are no risks in participating in this research.

4. **Duration**: The entire practice will take less than 20 minutes.

5. **Statement of Confidentiality**: Your participation in this research is confidential and anonymised. No personally identifiable information will be neither associated with the data nor used in publications.

6. **Rights to ask Questions**: Please contact the investigator if you have any questions at any time.

7. **Voluntary Participation**: Your decision to be included in this research project is voluntary. You may stop at any time. You do not have to answer any questions that you do not want to answer. Refusal to take part in or withdrawal from this study will involve no penalty.

8. **Use of material**. This material will only be used for demonstration purposes in this course or future paper or thesis publications, you data is confidential and anonymised. You have the right to revoke the permission of using this data at any time, just contact the investigator through the email provided in this form and let him know your decision. You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below. A copy of this form will be hand out to you at the end of the experiment.

_____ _____

Participant Name & Signature Date

_____ _____

Person Obtaining Consent (Investigator) Date

APPENDIX 3: QUESTIONNAIRE 1

Indoor mapping by using gamification – Study overview

Participant number: _____

The purpose of this form is to tell you about the experiment and to inform you about your rights as a research volunteer. If at any time you feel unable to continue participating in the experiment (for whatever reason), please inform the investigator and you will be released immediately. There is no deception involved in this study. So, please ask any questions that you may have about the study, what you will be asked to do, and so on.

We are collecting data from about 20 participants to help us to compare two version of an app intended to perform indoor mapping, and our studies could not be completed without your help.

You will first be asked to fill out a brief questionnaire at the beginning of the test. This questionnaire will ask general questions about your background basically with gamified applications. Then, you will be asked to perform indoor mapping tasks using two version of a mobile application in a device given by the investigator. You may ask questions about the test at any time during the experiment. The investigator will explain the procedure in more detail at the beginning of this phase. At the end of the study, you will be asked to fill out another short questionnaire about the test.

From start to finish, the test should take approximately 20 minutes.

Please turn this page and fill in the initial questionnaire.

Questionnaire 1 Participant number: _____

Indoor mapping by using gamification - Information about yourself

In order to analyze the results from this study, it would be very helpful if you could provide us with some information about yourself. This information will only be used in the context of this study, and will not be passed on to a third party. If we publish the results of our research, we will anonymise all personal information so that it will not be possible to identify the individual that produced it.

1. Please tell us your age.

❍ 20-30 ❍ 31-40 ❍ 41-50 ❍ 51 and older

2. Please tell us your gender.

❍ male ❍ female

3. How often do you play computer games?

❍ daily ❍ once a week ❍ once a month ❍ I do not play computer games

4. Have you ever used gamified applications where you receive score, badges or any other kind of reward for your interaction with those applications? (e.g. stackoverflow.com, tripadvisor.com, duolingo.com, foursquare.com, etc.)

❍ yes ❍ not (if your answer is not, please finish the questionnaire here)

5. How would you rate your expertise as a user of gamified applications?

❍ none experience ❍ inexperienced ❍ some experience ❍ experienced ❍ very experienced

6. Do you think the game elements (badges, score, ranking, rewards, etc.) you experienced in gamified applications before, are part of what motivates you to use them more often?

❍ yes ❍ not

Thank you very much for your help.

APPENDIX 4: QUESTIONNAIRE 2

Questionnaire 2 Participant number: _____

Indoor mapping by using gamification – Your thoughts

Please read the following statements carefully and then tick one of the circles to indicate your answer.

1. Which mobile app did you try first?

❍ gamified ❍ non-gamified

2. Which mobile app would you use in case you want to perform indoor mapping tasks?

❍ gamified ❍ non-gamified ❍ No difference

3. How many indoor elements (corridors, doors, entrances, stairs, etc.) did you map over the floorplan in the first try with the app?

4. In the gamified version, please rate the game elements.

Score	I did not liked ❍ ❍ ❍ ❍ ❍ Totally enjoyed
Leaderboard	I did not liked ❍ ❍ ❍ ❍ ❍ Totally enjoyed
Ownership map	I did not liked ❍ ❍ ❍ ❍ ❍ Totally enjoyed

5. Did you feel encouraged to improve you score and compete against other users when you used the gamified version by mapping more indoor elements?

Absolutely Not ❍ ❍ ❍ ❍ ❍ Absolutely Yes

6. Did you have fun when used gamified version?

Not fun at all ❍ ❍ ❍ ❍ ❍ Total fun

7. Would you contribute doing indoor mapping of the building of the University of Muenster in your free times by using any of the apps you just tested?

Absolutely Not ❍ ❍ ❍ ❍ ❍ Absolutely Yes

8. Do you think it would be more fun to use the gamified version app in teams?

Absolutely Not ❍ ❍ ❍ ❍ ❍ Absolutely Yes

Please write **any further comments** below:

Thank you very much for your help.

APPENDIX 5: Answers to questionnaire 1

Age	Gender	computer games	Use gamified applications	Experience in gamified applications	Motivation in game elements
0=20-30, 1=31-40, 2=41-50, 3=51+	0=M, 1=F	1=never, 2=once/month, 3=once/week, 4=daily	0=Yes, 1=Not	1=None, 5=Very Experienced	0=Yes, 1=Not
1	1	3	0	2	0
1	0	2	1	1	
1	1	2	0	1	0
0	1	3	0	3	0
0	0	1	0	3	0
0	1	3	1	1	
0	0	3	0	3	1
0	1	2	0	4	0
1	0	2	0	3	1
0	0	4	0	3	0
0	1	2	0	2	0
0	0	3	0	4	1
1	0	1	0	3	0
0	0	3	1	1	
0	0	1	0	3	1
0	1	1	1	1	
0	0	3	1	1	
0	0	3	0	5	0
0	1	1	1	1	
0	1	1	1	1	
0	1	2	0	3	0
1	0	1	0	2	0
0	1	1	1	1	
0	1	1	1	1	
0	1	3	1	1	
1	1	2	0	3	0
0	0	2	0	2	1
0	0	1	1	1	

APPENDIX 6: Answers questionnaire 2

App tried first	Preference for indoor mapping	Indoor elements mapped	Score	Leaderboard	Conquest map	Encouraging	Fun with gamified version	Would contribute doing indoor mapping	More fun in teams
0=gamified, 1=non-gamified	0=gamified, 1=non-gamified, 2=No difference		1=Not liked, 5=Totally enjoyed	1=Not liked, 5=Totally enjoyed	1=Not liked, 5=Totally enjoyed	1=Absolutely Not, 5=Absolutely Yes	1=Not at all, 5=Total fun	1=Absolutely Not, 5=Absolutely Yes	1=Absolutely Not, 5=Absolutely Yes
0	0	10	4	4	5	4	4		4
1	0	2	4	5	5	4	5		4
0	0	6	3	5	4	4	3		5
1	0	5	4	3	5	5	5		4
0	0	1	5	3	4	4	4	4	5
1	0	6	2	4	5	4	4	4	5
0	0	12	4	3	5	4	3	3	3
1	0	9	2	3	4	2	3	3	5
0	2	9	5	3	4	2	4	4	1
1	0	4	5	5	5	4	5	4	5
0	0	3	4	4	4	5	5	4	3
1	0	10	4	5	4	4	3	3	5
0	0	9	3	4	5	4	4	5	4
1	0	4	4	4	5	5	4	5	5
0	2	4	3	5	5	3	5	1	4
1	2	8	5	5	5	5	4	5	5
0	0	3	3	3	5	4	3	4	2
1	0	8	4	5	5	5	5	4	5
0	0	8	4	4	4	4	4	4	3
1	1	9	4	4	4	2	3	2	3
0	0	4	3	4	2	4	4	3	5
1	0	14	4	4	5	5	5	5	5
0	0	2	4	3	4	4	3	4	5
1	2	3	3	3	3	2	2	2	3
0	2	3	3	3	4	4	3	4	4
1	2	1	2	3	3	4	2	3	3
0	0	7	4	3	4	4	3	3	4
1	2	1	4	1	1	1	3	2	4

APPENDIX 7: SPARQL Queries

```
--Query 1 - Location of a building (please execute in http://data.uni-
muenster.de/php/sparql/):

            prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#>
            prefix lodum: <http://vocab.lodum.de/helper/>
            prefix db: <http://dbpedia.org/ontology/>

                  SELECT DISTINCT ?building ?buildingname ?lat ?long
?wkt WHERE {
                  ?hs a foaf:Organization ;
                  lodum:building ?building .
                  ?building geo:lat ?lat .
                  ?building geo:long ?long .
                  ?building foaf:name ?buildingname .
                  }

--Query 2 - select all mapped floorplans:

      SELECT DISTINCT ?floor ?escapePlan ?source ?cropped ?id WHERE {
                  ?floor a <http://vocab.lodum.de/limap/floor> .
                  ?floor    <http://vocab.lodum.de/limap/hasEscapePlan>
?escapePlan .
                  ?escapePlan
<http://vocab.lodum.de/limap/hasSourceImage> ?source .
                  ?escapePlan
<http://vocab.lodum.de/limap/hasCroppedImage> ?cropped .
                  ?escapePlan <http://vocab.lodum.de/limap/id> ?id .
                  }

--Query 3 - retrieving players and their scores

PREFIX prv: <http://purl.org/net/provenance/ns/>
PREFIX indoor:<http://data.uni-muenster.de/context/indoormapping/>
SELECT DISTINCT  ?x ?email ?nick ?totalScore ?registrationDate  WHERE
      {
            GRAPH <http://data.uni-muenster.de/context/indoormapping>
            {
                  ?x rdf:type prv:Player .
                  ?x foaf:nick ?nick .
                  ?x foaf:mbox ?email .
                  ?x indoor:hasRegistrationDate ?registrationDate .
                  ?x indoor:hasTotalPlayerScore ?totalScore .
                  ?x indoor:hasPersonBadge ?badge
            }
      }
      ORDER BY ?totalScore
```