Gamification Outside Physical Borders

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Abstract—The motivation for this work came from the belief that our civilization is becoming more connected to the "virtual" world, and that users are using virtual communication tools to be able to communicate, mostly without the need to communicate face to face. This leads to a more closed environment, where people exit their houses only when needed (get groceries, go to work, etc).

By viewing positive effects of games on players, and using them in non-game contexts, gamification was created, and is already being used and researched with many approaches, but there is no research regarding its use on outdoor activities, as a motivator for people to exit their homes.

For this purpose, we approached this topic and developed GeoChest as a possible solution. GeoChest combines Gamification and GeoCaching, an outdoor activity, in an attempt to understand which gamification techniques and mechanics can bring a positive feedback from the users that use the application.

In the end, we concluded that not only the application was well-designed, but also that most of the application's game mechanics implemented were well-received by the users, ending this dissertation with the belief that we were able to bring some interesting contributions to Gamification research.

Index Terms—Gamification, Outdoor Activities, Geocaching, User Satisfaction, Motivation

I. INTRODUCTION

Games are nowadays a powerful tool, either for companies, researchers, or actual players. According to the Entertainment Software Association latest report of 2016, *Essencial Facts about the Computer and Video Game Industry*[1], 65% of U.S. households own a dedicated game console, and 63% of americans play video games regularly (3 hours or more per week). By registering 23.5 billion dollar sales in the year of 2015, the video game industry is currently one of the most profitable industries for the beginning of this decade, and also one of the most influential.

Companies, seeing the players' commitment to games, created the concept of gamification, that is the use of game mechanics and techniques, along with game design, in applications that contain no game context, in order to engage customers around in their products. With success cases like FourSquare[2], research teams around the world studied the concept, in order to understand its impact on society.

As technology created the means to contact with people far from our current location, such as friends and family in another country, this contact is creating a physical distance between people close to them. People nowadays are used to communicate using mostly their mobile devices, without leaving home, than to meet physically on a public location such as a garden or a library. That friction created by the technology is already visible on young adults. For instance we have social dysfunctions such as Hikikomori[3] reported on Japan, mostly found on some of the most technologically developed cities.

The motivation for this work comes from the belief that we can develop applications that motivate people to be outside their homes. There are already some well-known examples that show this to be more than a belief, like Ingress and Pokémon GO, both made by Niantic Labs. This work is meant to validate which game mechanics used in gamification allow to influence more users to get outside.

The final goal of this work is to understand which game mechanics can create an impact on users, for outdoor activities.

The rest of the document is structured as follows: first, in Section II, we present the background and related work, where relevant subjects are introduced and analyzed to create a basis for the reader. In Section III, we describe our solution, from its inception to the final product. We will describe the rationale for building the application, and tests that were made from inception to development phases, in order to have it ready for the testing phase. In Section IV, we present the two tests made with our application: the quantitative test, which was made with 24 users in a 2 full-week period in a uncontrolled scenario, and; the qualitative test, which consisted of interviews conducted to people with different experiences on GeoCaching. Finally, on Section V we finish this document with the conclusions taken from the evaluation results and from the developed application itself, and future work identified.

II. BACKGROUND

To provide a general idea of the challenges present in this topic, we will describe Motivation and Performance applied in gaming, and Gamification and its usage, as the basis for the created solution.

A. Motivation and Performance

Researchers have found that games motivate people to many activities. Much of the work was done in controlled environments where people, mostly kids, were subject to experiences in which the purpose was to create good habits [1], [5] or to learn skills in training environments [4], [6], and

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see their reaction to those experiments. The results showed that gaming can motivate people to learn new skills [3] or to acquire good habits.

It is also said that passion is one of the factors that contribute for the motivation of a person in a videogame, and were analysed on a subject [7]. Results showed there are two kinds of passion: harmonious, normally bringing general positive affect towards the player, motivating him, and obsessive passion, bringing the negative affect.

Additionally, performance was also studied [2], [4], and the reports showed that subjects that frequently play games have increased visual acuity and motor skills. Also, in the same study, task difficulty was evaluated, and as the players got used to the task at hand, the difficulty becomes less than an obstacle: experienced players had better performances, independently of the difficulty imposed on them, and inexperienced players demonstrated the worst performance levels.

Finally, in one of the studies mentioned above [1], there was a more significant dropout in the home group (single player), with 64%, than in the multiplayer group, with 15%, which could mean that a multi-player environment better motivates the player than a single-player.

B. Gamification Definition and Story

Gamification is a term created very recently and, according to the Oxford dictionary, is *the application of typical elements of game playing (e.g. point scoring, competition with others, and rules of play) to other areas of activity, typically as an online marketing technique to encourage engagement with a product or service.*

This term was first coined by Nick Pelling in 2003. According to his blog, its purpose was, *to make electronic transactions both enjoyable and fast.* He started a company named Conundra Ltd, that used gamification as is motto, but eventually came to an halt on 2006, due to no significant customer interest. Only in 2010, gamification had its popularity increased, since *Foursquare*, a well known local search and discovery gamified application, had been run for about one year and has gained since then, according to its site, 55 million users across the world. Also on that year, DevHub, a website that lets users create their own blogs and web sites, added a point system to its website, and saw an increase of user engagement. Later, on January 20, 2011, the first gamification summit was held in San Francisco, California, and all tickets were sold out, according to the official site. In 2012, about 45 thousand people enrolled in professor Kevin Werbach's online Gamification course, through Coursera.

In research terms, it was in November 2010 that gamification came to be known, when Gamification Research Network was launched, alongside the call for participation for the 2011 CHI workshop on gamification[4]. Currently, the Gamification Research Network has more than 360 subscribed verified researchers, and it has become the main channel of reaching gamification reserachers around the globe.

[4]http://gamification-research.org/chi2011/

In order to apply gamification, we need to identify the game elements that we can apply to non-game contexts. Those game elements are normally known as game mechanics, which are used then as gamification techniques.

Gamification techniques strive to leverage people's natural desires for socializing, learning, mastery, competition, achievement, status, self-expression, altruism, or closure. The opportunity for a user to appear on a leaderboard, or to attain a certain status can influence him to execute some actions that, in most cases, the user would not. We use game mechanics to achieve these status.

Game Mechanics are the mechanisms used by game designers to reward activity among customers, employees or other users. There are many game mechanics available, such as Achievements, Behavioural Momentum, Points, Urgent Optimism and Virality, and each of them are used in favor of the Gamification Techniques that the company or research team would want them to apply.

III. SOLUTION

In this chapter, we will approach the developed solution, GeoChest.

GeoChest is a Gamified Geocaching application. *Geocaching* is an outdoor recreational activity, in which participants use a Global Positioning System receiver or a mobile device, and search for hidden waterproof containers across the world, *geocaches* or *caches* for short. In most of the cases, Geocaches contain a logbook where people that find the container can register their nickname and the date when they found it.

We recorded in the application a total of 25 geocaches, with 15 of those being themed caches (5 trios of caches), and the rest non-themed. We made it this way so the application has more variety and the user could choose where to go and which caches to get. All caches were created by third-parties, and we requested their approval to use their caches for this application.

The application is similar to Ingress and Pokémon GO, having specific locations where people can receive rewards, but with the major distinction that GeoChest has physical items located in those locations, while Ingress and Pokémon GO are completely virtual, with no contact with the real world apart from the real location tracking. Additionally, in GeoChest we can create accessories we can equip on our character, while on Ingress and Pokémon GO we don't have equipment, and there's no crafting options.

As for the application's theme, we decided that the theme for the application would be a pirate-y one, since Geocaching is very similar to Treasure Hunt, one activity that is frequently related to piracy. In this application the user is a pirate searching for a *treasure*, which is represented by the geocaches present on the application. As a pirate, the user should look for thos treasures, in order to get special coins that will enable the user to trade those for metals and gems. Those gems and metals can then be used by the user, and transformed into jewelry, which can then be equipped into your pirate.

As for the user interface, we decided to design a simple layout, with an horizontal action bar present on the upper side, for user location on the application and quick action buttons (see Figure 1). This allows the user to have a simple and clean experience in order to not disrupt him from the purpose we want the application to have. This layout is already used in several Android applications, such as Google Play Store, Google Sheets or Google Keep, and allows the user to focus itself on the application's content, without the need to learn and understand the interface, since it should already be known by the users.

We also use native icons already present on Android for the user, so he does not need to learn new icons. For some cases we needed to create our own icons, for the intent of the action buttons in the action bar to be as explicit as possible.
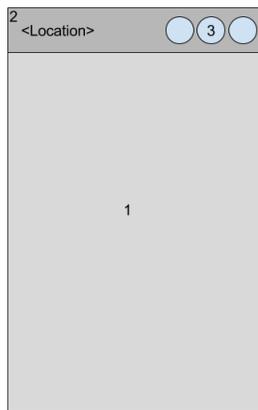

Fig. 1: GeoChest Screen Layout. 1 - Screen; 2 - Action Bar. In the left side you can find the current location of the application to the user; 3 - Quick Action Buttons. These allow the user to access other screens on the application.

When the application is first opened, the user will have to make 2 configuration steps: first, he will choose the character's gender, which will be shown on the Character Screen, and; second, he/she will write a nickname for the character. These steps will only happen once, and the character cannot edit those, once the choice is made.

The application's behaviour focuses on two different fronts: the geocaching activity by itself, and the gamification part. This represents the 2 action plans which the player can interact with.

For the geocaching activity, it consists of finding a certain cache located on a specific location. The player travels to the exact location of the geocache and searches for it. Once the geocache is found, he can register his name in the logbook (optional) and register a code present on the geocache container. The code is an alphabetic and numerical 8-character long string, automatically generated by Random Code Generator[5]. There was another approach, in which we also take into consideration the player's location, compare it with the location of the cache, and wait for the log code

[5]https://www.randomcodegenerator.com

to be put, serving as an additional validation. We chose the first approach from these two, because the second approach would consume more development time, and it is not part of the application's main goal. Once a code is registered, the player receives 1 gold coin or 2 silver coins, depending on the geocache's type.

There are 2 different types on this application: Themed or Non-themed. The themed caches are a trio of caches, close to each other, with the same theme. The available themes are Fantasy, Sci-fi, Fable, Horror and Adventure. The non-themed caches are spread out across the various locations. Themed Caches give 1 gold coins, and non-theme caches give 2 silver coins.

All geocaches were made by third-parties, and the permission to use those caches for this application was requested to all respective owners.

As for locations, we decided with 3 different locations: Sintra village and mountains, and also Oeiras and Lisbon, where two campi of Instituto Superior Técnico are located. This choice was motivated by the fact that most of the potential testers for the quantitative test were students. As such, we put some caches near both campi, and others spread across Lisbon and Sintra, for people who would want to take on a challenge. This allowed us to engage both people that want a simple and easy test, and people who would want a bigger challenge, by searching in non-frequent places.

The second action plan, which is the gamification part, is more comprehensive, since the player has several possible actions that could be done:

1) Customize your character: the user has access to his character, which is male or female, depending on the choice that was made by the user in the beginning. The character can be customized in two different ways: titles and equipment. Titles allow the user to have a title in his character's name (for example, *Fast Discoverer* Steven). As for equipment, the character can have 2 rings, 2 bracelets and 1 necklace;
2) Create your equipment: the user can create accessories for his character, by using resources bought in the shop;
3) Buy Resources: the user can spend his coins on the shop, to buy resources. There are 3 different resources: gems, metals and paint buckets;
4) Check Achievements: the user can visualize all possible achievements in the Achievement Screen, if he achieved those or not, and possible unlocked titles associated with those achievements;

As for the solution architecture, we decided on an application that was mostly offline, only needing to be online for two different situations: 1) Tutorial videos that were put on Youtube, and 2) When sending the log information to the database. There was an intention to have a server-client application, but lack of resources and lack of time made this solution infeasible on a short period.

We decided to put the videos on Youtube to avoid occupying unnecessary memory space on the user's phone, thus being able to work even on older smartphones. Additionally, we do

not know if the user's smartphone has local video applications ready to reproduce them. As such, we decided to put those videos online, and make a direct connection to those. We also made a local cache on the application, so that image processing could be as fast as possible. For that we used parallel threads so the processing is made outside the main thread, which controls the UI. After that, we made the main thread access that cache, in order not to consume processing from the main thread, which is vital for the correct execution of the application.
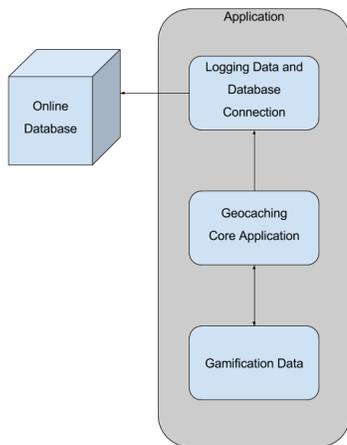

Fig. 2: GeoChest Architecture.

Figure 2 presents the architecture for the application which is composed of 3 different modules:

- Geocaching Core: this is the main module, which focuses on the geocaching activity itself. The Geocaching Core Module is able to register every geocache and update the application for geocaches that were already collected or geocaches that were still not obtained, in order to show them to the user, as already mentioned on Section **??**. It comprises of the MainScreen and CacheScreen, along with the help screens related to those.
- Gamification Data: this module contains all the Gamification information, which includes achievements, titles, character customization, etc. We mention every gamification data that was included on the application, and how to access that information from the user's perspective in Section **??**. It comprises of the CharacterScreen, AchievementScreen, CraftingScreen and ShopScreen, along with the help screens related to those;
- Logging and Database Connection Module: this module has 2 different functions: the first one is to save information regarding users' actions towards the application, e.g. screen times and titles that the user obtained, and the second one is to send that information at the end of the testing period to the online database located at Instituto Superior Técnico. The information sent was:
  - User's GPS coordinates. This will only send the GPS coordinates when the application is open, and on the Main and Cache screens;
  - Achievements. All achievements are sent, with a true or false flag, depending on the user completing or not that achievement;
  - Caches. All caches' information about being completed or not are sent, also with a true or false flag;
  - Character information, more specifically its' name, gender and current title.

This module comprises of a class (with no screen associated) that deals both functions defined in the beginning.

The application is able to be installed in versions 4.0 and above. The decision to do this was related to the fact that Android suffered some great changes regarding location tracking and layout performance in versions prior to 4.0, so we needed to either push the application back to some older versions, or have it more updated to cover other recent smartphones. We decided for the second one, as our smartphones had Android's 4.0 version installed, and the location tracking was locked to smartphones that had the Google Services application, which is only present on actual smartphones. This means that emulating smartphones was not possible for testing, which removed the first option as a possible solution.

Finally, the permissions that we requested from the user for the application included location-tracking, either fine or coarse locations, respectively to use the Android Network Location Provider and Global Positioning System. This allows for better understanding the user's exact location. We also requested permission for external storage access, in order to have the local cache. Finally, in order to access YouTube, we requested access to the internet, for the user to be able to send his log information, and watch the YouTube tutorial videos.

As for game mechanics, there were a total of 8 game mechanics implemented on this gamified application: achievements, character customization, crafting, currency management, ownership, progression, status and titles. The Discovery mechanic will not be approached, since GeoCaching main focus is in the Discovery mechanic, with the user being able to discover the cache on real life. The **Countdown** mechanic will not be approached as well, as the 2 full weeks for the testing phase are not meant for the mechanic to be used and the application can be kept by the user after the testing phase.

- **Achievements**: There are a total of 19 achievements for the user to obtain, defined into 4 different types: cache achievements, related to finding a certain number of caches; themed achievements, related to the themed caches; location achievements, related to the location of the caches found, and timed achievements, related to how much time the user dedicated to find those caches. The existing achievements (and titles) are listed in Table I. Initially, we considered on having secret achievements, as a **Discovery** measure, but since Geoaching has already this mechanic, we removed this feature, since the impact would not be as much as those of this list, specially for testers that already do Geocaching.
- **Character Customization**: There are two ways to customize your character. The player can:

- Associate a title to the character: any title that the user unlocked can be associated with the character. Only one title can be equipped with the character;
- Equip accessories: a character can have 1 necklace, 2 rings and 2 bracelets equipped at the same time. Those accessories can only be crafted, by using the **Crafting** mechanic.

- **Crafting**: Crafting is the act of creating items, using resources bought in the shop. There are a total of 180 accessories that can be created from all existing resources: 3 accessory types, 6 different gems, and 5 different metals, with one of the metals needing to be painted with 1 of 6 different colors. We decided to give as much freedom to the user as possible with those combinations.

All created accessories have the same formula for its name:

(<Metal>/<Color>)<Jewel><Accessory Type>

If the metal used for the accessory is Aluminium, we instead it call by the color used, since this metal needs a bucket of paint for its color. For other cases, we use the metal used on the accessory name. In Table III, we present all existing resources in this game.

This mechanic was one of the game mechanics that evolved the most during its design:

- In the first iteration, the purpose of the crafting mechanic was to build a major trinket at the end of the game, contributing to the **Status** and **Progression** mechanics. The first iteration had the same 5 themes associated with the caches and, upon finding each trio of themed caches, a specific gem was given to the player, depending on the theme. The non-themed caches gave base resources to create the trinket. Upon finding all 25 geocaches, the player would be able to create the *Cacher Medallion*, which would be the pinnacle of both mechanics mentioned above. Unfortunly, we verified this to be a very linear progression, and no freedom of choice was given to the player;
- In the second iteration, we decided to give as much freedom to the player as we can. This iteration is quite similar to the current approach used on the application, with some additional features: first, there was an additional accessory type called the medallion, which would be a bigger version of the necklace. The user could use 1 necklace and 1 medallion at the same time; second, we had a 6th metal, *Steel*, with a steel gray color; third, we had 1 additional gem, instead of the current 6, with *Topaz* having the yellow color; the crafting recipe for creating a certain accessory would depend on the rarity of the accessory and the accessory itself (see Table II).

We decided to remove those additional features because of memory and mobile design potential issues. Since this application would run on every Android smartphone, independent of the phone dimensions, this mean we should verify if the images would be clearly perceived from every dimensions. As such we verified that: 1) the steel metal could cause some confusion for silver and tungsten, which have a light and dark gray color already. For this reason, we removed steel; 2) the topaz gem could be confused with not only the gold metal, but with the amber gem, depending on the phone dimensions. This led to the gem also being removed; 3) the crafting itself could be confusing with the different values needed, and it would imply further analysis of how the resource management could have a balance between number of resources of each type and the difficulty for buying those resources. Thus, we decided to have a simple recipe manual, with 1 metal making a ring, 2 equal metals for a necklace, and 3 equal metals for a bracelet (this does not remove the Aluminium case which requires an additional material, a bucket of paint). Finally, we also removed the medallion, since it would only be a bigger version of the necklace, as already mentioned. With all these additional features, we would escalate the already 180 accessories to a total of 308 different accessories, which would mean more memory space used in the smartphone for image processing, and a bigger cache for the processed images. This resulted in the current design for the crafting mechanic, which is based on the following recipe: 3 equal gems and 1 to 3 equal metals. For the Aluminium case, we need an additional bucket of paint. So, for a *Gold Ruby Necklace* we need 2 Gold (metal) and 3 Ruby, as for *Purple Emerald Ring* we need 3 Emeralds, 1 Aluminium and 1 Purple Paint.

- **Currency and Resource Management**: When a user finds a cache, and successfully logs the cache in the application, the user will receive either 1 gold coin or 2 silver coins, depending on the cache type. This means the user can have a maximum of 15 gold coins, and 20 silver coins, and, consequently, 15 gems and 20 base materials for accessories. With only 15 gems, the person is limited to have only a maximum of 5 accessories. We want the user to manage his currency and resources, by forcing them to make a choice upon the resources that the user can gain.

This currency was initially to be two different keys, which would enable the user to open chests, and receive random items, focusing on the **Lottery** mechanic, but it was quickly discarded, as it can have a negative impact for the user due to the randomness provided in such a short period, so we switched to coins. We want the user to have control over the game, and to not be dependent on luck;

- **Ownership**: The user owns a character, and decides on which title he associates to the character, and which equipment it has equipped. The only change that occurred was the inclusion of both a male and female character, to have both genders on the application. This does not bring

any advantages, and the gender choice will only affect the image that will be shown on the Character Screen. This gender can only be chosen at the application setup, and it cannot be switched.

- **Progression**: In the bottom of the Character Screen we can see a chest, that initially will be empty. This chest is related to the number of caches that were found. The chest can go through 4 states, going from empty to full, depending on the percentage of geocaches that were caught.
- **Status**: The equipment and titles that the character has are used as a **Status** mechanic, which can be then shown to other users (outside the activity). This means that the Character Screen was created with an intent to be visible to other users, if the application allowed some sort of social interaction.
- **Titles**: There are a total of 13 titles that can be obtained from the user. Those titles serve as part of the **Status** mechanic, which will enable users to have a Status associated with the user. For example, having the *Survivor* title used serves to show that the user got all Horror-themed caches. It can also be seen as part of the **Progression** mechanic as well. as there are titles related to the number of caches obtained. There was a older version, in which the title would be on a different place, showing right above the character's head, on the Character Screen, instead of being right before the character's name, on the action bar. For consistency reasons, we remove that field from that place, and we created an icon on the action bar which, when clicked on, will leave the player to a new field, where the player can choose his title from the ones that are available.

Finally, we are using game mechanics that the user can more easily perceive, in order to be as easy as possible for the user to separate and order them by preference in the questionnaire after the test period ends.

IV. EVALUATION

This phase was divided into 2 different tests: quantitative and qualitative.

Starting with the quantitative test, during the project development, there was a need to test the application in the most realistic environment possible. This led to the quantitative test.

A. Quantitative Test

This test consists on getting as many people as possible testing 2 versions of the application: one containing all game mechanics already mentioned before, while the other was a simple Geocaching application, without gamification features. Since we divided both gamification module and geocaching module, we could easily remove the connection between those modules, by removing the icon which would give access to the Character Screen.

In order to confirm the user is finding the geocaches, we had used random codes which were later put on every cache, to confirm that the caches are still on the desired

Achievement Name	Description	Title Unlocked
Initiate Cacher	Find your first cache.	-
Junior Cacher	Find 5 total caches.	Count of Caches
Experienced Cacher	Find 10 total caches.	-
Senior Cacher	Find 15 total caches.	Duke of Caches
Master Cacher	Find 20 total caches.	-
Grand Master Cacher	Find all 25 caches.	Emperor of Caches
The Final Frontier	Find 3 Sci-fi-themed caches.	Space Explorer
Atlantis	Find 3 Fable-themed caches.	Historian
Wonderland	Find 3 Fantasy-themed caches.	Cheshire Cat
Elm Street	Find 3 Horror-themed caches.	Survivor
Hyrule Castle	Find 3 Adventure-themed caches.	Adventurer
Moorish Castle	Find 5 caches in Sintra.	-
National Palace of Pena	Find 10 caches in Sintra.	Sintra Explorer
Jeronimos Monastery	Find 5 caches in Lisbon.	-
Monument to the Discoveries	Find 10 caches in Lisbon.	Lisbon Explorer
Gotta Go Fast	Find 3 caches in 1 day.	Fast Discoverer
Weekend Cacher	Find caches over consecutive 2 days.	Casual Tester
Weekday Cacher	Find caches over consecutive 5 days.	-
Full-time Cacher	Find caches over all test days.	Hardcore Tester

TABLE I: GeoChest list of achievements and titles.

	Aluminium	Tungsten	Copper	Silver	Gold
Ring	1	1	2	2	2
Bracelet	1	2	2	3	3
Necklace	2	3	3	3	4
Medallion	2	3	4	4	5

TABLE II: Old Crafting table for metals and accessory types.

Resource	Type	Coin Used
Amber	Gem	Gold
Amethyst	Gem	Gold
Diamond	Gem	Gold
Emerald	Gem	Gold
Ruby	Gem	Gold
Sapphire	Gem	Gold
Yellow Paint	Paint	Silver
Blue Paint	Paint	Silver
Black Paint	Paint	Silver
Purple Paint	Paint	Silver
Green Paint	Paint	Silver
Red Paint	Paint	Silver
Aluminium	Metal	Silver
Bronze	Metal	Silver
Silver	Metal	Silver
Gold	Metal	Silver
Tungsten	Metal	Silver

TABLE III: List of resources, and their cost in the application.

place, not impacting the experience for the testers. There were some changes that happened due to this preparation, as some planned caches were missing from their places. This led to change some caches' locations, before the tests ended.

The testing phase took place on June 3rd, and ended on June 19th. Using the social media, we talked with the Instituto Superior Técnico community and with the portuguese Geocaching community and released a form, in which those those interested in participating would indicate the email to which we should sent the application, on the beginning of the testing phase. The real-time test with the application, by the participants, was on a uncontrolled environment, with the intention of not influencing the results and there was no direct contact with the testers. The whole process was online, without the need for both us and the testers to encounter on a face-to-face situation or schedule any interview.

We got a total of 24 people that displayed interest in testing the application and we randomly selected 12 people that would use the gamified application, with the other half using the non-gamified version. We sent an email to every person with instructions on how to install the application on their smartphone, and briefly explaining the application itself. During the testing phase, everyone could contact us, in case of any question or issue regarding the application (as Android applications are more difficult to have a stable version, due to the number of different smartphones that have Android as their operating system).

After the testing phase, participants answered a questionnaire available on the internet. The questionnaire itself has 2 versions, one for the gamified version, and other for the non-gamified version. The questionnaire links would be sent on the day after the last day of the testing phase, June 20th, to the designated testers, for each version.

The questionnaire consists of 4 parts:

- Usage of the application: for how many days the user used the application, during the testing phase. This would allow us to understand how much the application was used, and cross it with the information of the next parts;
- Mechanics: this would ask the tester to state, on a scale of 1 to 7, with 1 being "Dislike" and 7 "Like", how much the tester liked each mechanic of the game. The main difference between the gamified version and non-gamified version of the questionnaires, is the inclusion or not, respectively, of this part on the questionnaire;
- Overall Satisfaction: for this part, we used the System Usability Scale[6], and verified the user experience with the application. We also added a question related to the help screens, and what they thought of those screens;
- Personal Information: in this screen we gathered an interval of ages in which the user belongs, how often the user did geocaching before the testing phase, and his/her character's name, which would be located on the Main Screen, on the Action Bar, accessible by both versions.

[6]https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html

During the test, there were some issues that happened:
- The first issue was due to some restructuring works being made on one location, which lead to the respective cache disappearing. We received feedback from two testers, referring that situation. This could have impacted the user's experience, but there was nothing that we could do to avoid this situation;
- The second issue is also associated with some caches disappearing from their locations, as some testers did not found those caches.

Both these issues were resolved by individually giving them the codes that were used on the caches, after confirmation that the caches were missing. Apart from that, no contact was made due to erroneous behaviour from the application, or any difficulty on installing the application.

After the testing period, the application would request the user to send the information to the database. Out of the 24 people that received the application, a total of 7 results were sent to the database. Out of those results, 2 people showed more progress than the rest of the users, with a minimum of 10 caches discovered.

As for the questionnaire, we got 10 total responses, 4 from the non-gamified version and 6 from the gamified version. Results show that most people that tested the application were 18-30 year old, with only one person in the 36-42 year old interval, and most of them did not had experience with the Geocaching activity. Figure 4 shows that, independently of the version, the application was well-designed, and the help screens and tutorials were seen as very useful for the user. In comparison, Figure 6 the users with the gamified version used it for more days than the users with the non-gamified version. But, as the "additional comments" section mentioned, of those 10 users, 3 users did not install the application, and with data from a sample of only 7 people, out of the 24 that executed the tests, we cannot reach a solid conclusion.

As a consequence, we found these results to be inconclusive and we decided to include the qualitative test.

B. Qualitative Test

The qualitative test consisted of an interview with two different groups of 3 people each: one group which tested the application, and had no background with Geocaching prior to the quantitative test; and a group of people that does geocaching as a hobby. We will call the first group A and second group B. Some of the interviewed have experienced this application beforehand, in the quantitative test.

In the interview, we showed the application to them, and explained the game mechanics one by one. Afterwards we asked some open questions to the user, regarding the overall user satisfaction with the application, its mechanics, and suggestions to improve the application, taking into account the user's experience with the Geocaching activity (see Appendix C). The interview was made through communication tools over social media, e.g., Facebook, Skype. We gave freedom of choice to the user as for the communication tool to use,
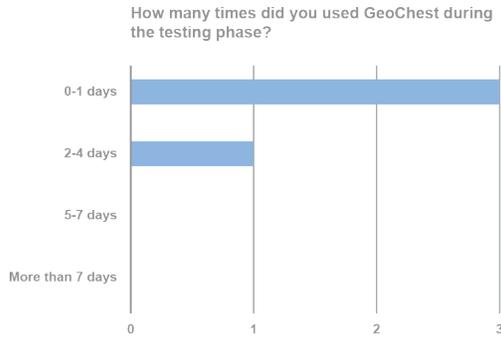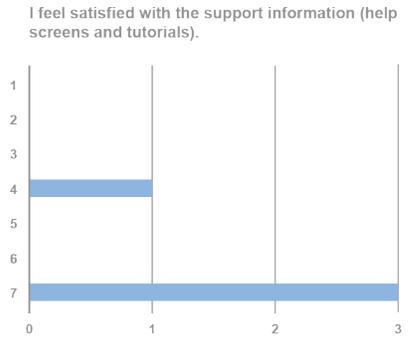
(a) Normal Version.
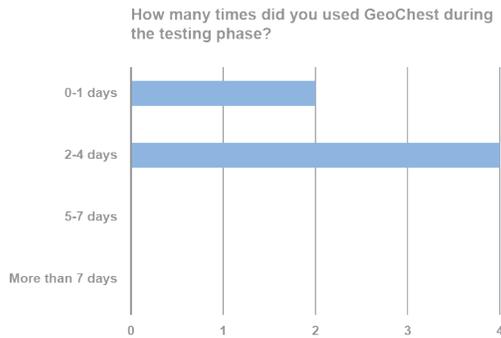
(b) Gamification Version.

Fig. 3: Comparison between both Versions of the Questionnaire, for the number of days the user used the application.
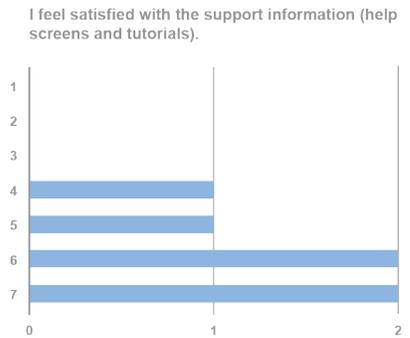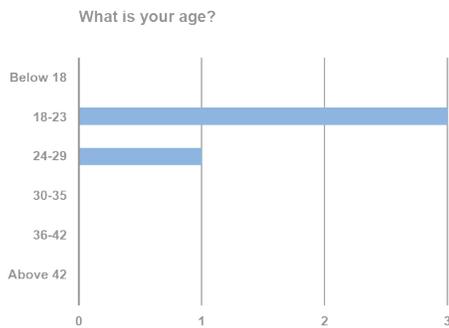

(a) Normal Version.
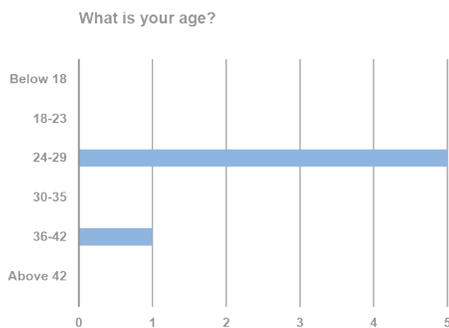

(b) Gamification Version.

Fig. 4: Comparison between both Versions of the Questionnaire, for the satisfaction of the user over the support information (help screens and tutorial videos).

and the interview was as informal as possible, in order for the user to feel comfortable during the session. We decided to do this approach to be easier for both the testers and the main developer to be available for the interview. The interview was scheduled to last not more than 20 minutes.

At the end of the interviews, we received a very positive feedback for the application, with the following results:

- For the people from Group A, their evaluation of every mechanic in the application was positive, with an overall average of 5.7 for all mechanics. As for the ones that were most liked, we observed that Achievements was the most liked, followed by Crafting, Ownership and Progression. As for the people from Group B, their evaluation of every mechanic was also positive, with an overall average of 5.8 for all mechanics (See Figure 7). As for the ones that were most liked, we observed that Achievements was also the most liked, followed by Titles and Status;
- Additionally, both groups agreed that all mechanics implemented were essential for the whole experience, and gave several suggestions to improve the experience, such as:
  1) **Achievements**: they should be more dynamic, giving more than titles, for example having also different completion icons (instead of the compass, used

for everyone), and different clothing, which we will mention with more detail on the Title section;
  2) **Character Customization**: one particular detail that the users found as a negative point was the fact that both name and gender could not be changed by the user. Additionally, the title that was selected at the moment could hide the character's name. In both cases, a simple reiteration over the application could have led to a better user satisfaction;
  3) **Crafting**: users referred that the crafted jewelry had simply an aesthetic purpose. Some said the crafted jewelry could have more impact on the application;
  4) **Currency and Resource Management**: A less positive point that was mentioned was the fact that, after a user buys a resource from the shop, the user cannot sell it afterwards. That had a negative impact, as some users did not want to commit to the risk of buying wrong resources; thus, they did not buy any resources, instead keeping the coins. Additionally, every cache successfully logged by the user should be more rewarding and less linear, e.g. giving random resources or more coins, or both. Users did not find the shop to be intuitive
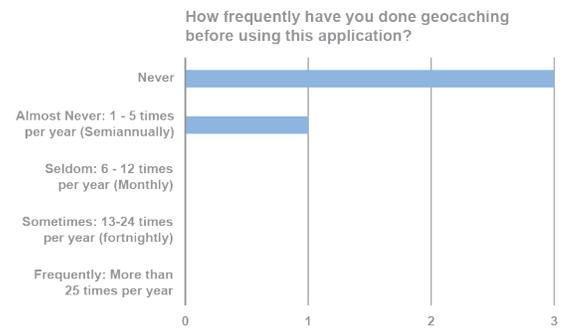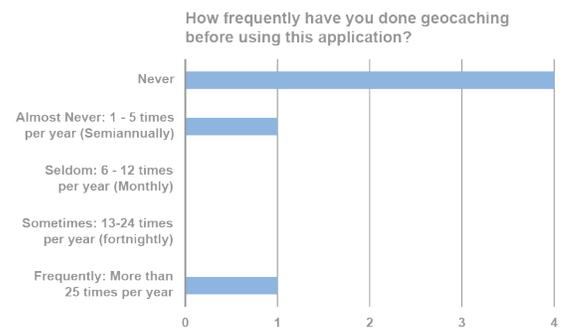
(a) Normal Version.

(b) Gamification Version.

Fig. 5: Comparison between both Versions of the Questionnaire, for the age intervals.

(a) Normal Version.
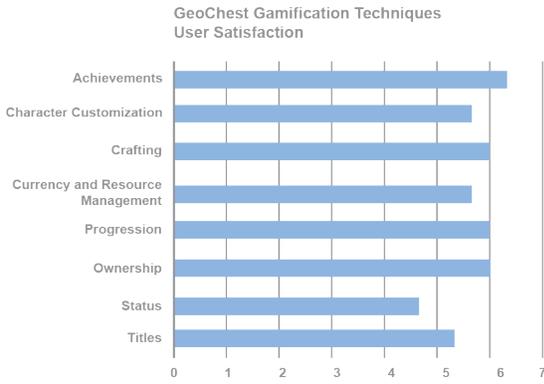

(b) Gamification Version.

Fig. 6: Comparison between both Versions of the Questionnaire, for the frequency of geocaching done by the users.

enough, since there is no information from the screen that says which coins are needed for buying the resources;

5) **Ownership**: One of the users said that it would be interesting to give the character a personality and stats, giving the application a Role-Playing approach. For example, giving the character a shy personality, and having this reflect in the way the character reflects on other characters. Additionally, we would have stats such as "Explore", "Luck", etc., which would have some impact on the application.

6) **Progression**: The chest was seen as not intuitive. Many suggested that the chest should feature an animation of it being filled with treasure, as every cache is logged successfully;

7) **Status**: Two different suggestions were made. The first consisted in having a social feature, in order to compare their status with other users that use the application. The second suggestion was that achievements could be seen as part of the status of the player, and should be seen on the Character Screen;

8) **Titles**: There was a suggestion for the title to have more impact than merely its name. The most

suggested addition was for the title to change the character art, and show different clothing. So, if the user completed the sci-fi themed caches and obtained the title, having the title displayed would change the character from a pirate-y costume to a sci-fi one;

- Group A also said that Geocaching, in its core, is quite monotonous and adding the gamification mechanics brought more enjoyment and experiences with the application, as well as a sense of fulfillment from the users; Group B said that this application would help motivating younger people, around the 19-30 age interval, but they were unsure regarding people outside that interval, who could see this application unnecessary and unwanted;

- From a social perspective, both groups commented that adding a social component to the application would provide interesting experiences: not only the Status mechanic would bring more impact, but also there would be more interactions between different players, both in collaborative or competitive spirit;

- Finally, there were some suggestions from Group A to edit the user interface. The most common one was to have a "main menu" screen, instead of opening the application directly on the map screen, and access every screen from

(a) Normal Version.
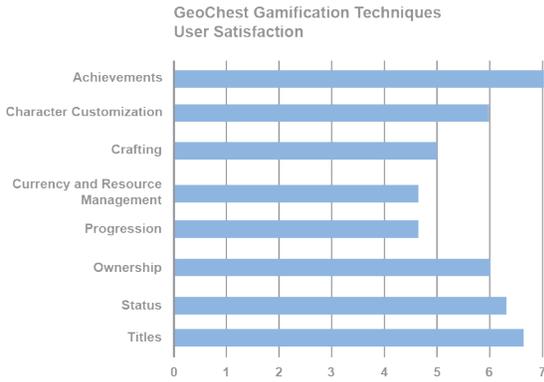
(b) Gamification Version.

Fig. 7: Comparison between both versions of the Questionnaire, for the average of the user satisfaction for both mechanics.

the main menu. Another suggestion was to give the user a notion of the difficulty of the geocache's location.

V. CONCLUSIONS

The quantitative test was performed by few participants (many of the volunteers did not install the application in order to complete it), even with a document describing the steps. However, for the users that used the application, results showed that the experience was positive.

For this test, we would need to reformulate the procedure, and instead of getting the testers to install the application themselves, we would need to arrange a way to be easier for the users to install it, e.g. making the application available on Google Play Store. This would allow for an easier installation, and would also give the testers a sense of trust, by downloading the application from the official store, instead of having to enable the installation of applications from untrusted sources. Still, by having the application on the Google Play Store, that would lead to either have advertising, or paying an amount for the application to be available on the store.

While the quantitative test gave us mixed results, communicating with the testers on the qualitative tests resulted in

the application being well designed, with many suggestions from both groups to improve the application. This could coincide with the point that we stated before: the installation process could be the main reason the quantitative test was not successful. This is still the expected behavior, as we developed the application to be as close as possible to a final product, with some improvements still needed from users' feedback.

Taking into account our goals from Section **??**, we can conclude that the first point was successfully done, with only some improvements to be made. The application was well designed, and from the interviews with both groups, all enjoyed the application as a complement to GeoCaching. For the second point, only with the second test we achieved some conclusions regarding the application's design, and which game mechanics were better designed according to the application's purpose, with Achievements having the best results. While there were some differences between both groups, all game mechanics were well received by all interviewees.

In the end, we believe there are some improvements that should be done for the testing phase, which could have improved our results. As for the application, it fulfilled its purpose as a motivator for people to exit their homes and explore their zone/region.

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