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Mobile Persuasive Interfaces for Public Ambient Displays

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Resumo

Através do uso de tecnologia persuasiva, é possível influenciar as atitudes e comportamentos das pessoas de modo a praticarem acções que possivelmente não fariam de outra forma. Assim, é possível utilizar esta tecnologia em vários domínios como a saúde, a educação, os negócios, a segurança e o ambiente, de modo a obter mudanças positivas.

Esta dissertação procura estudar e criar mecanismo para sensibilizar as pessoas para as consequências das suas acções nos recursos naturais do nosso planeta, os quais não são infinitos. Assim, foi desenhado e implementado o Gaea, um protótipo que introduz formas inovadoras de interacção entre dispositivos móveis e expositores públicos, aliado ao uso de tecnologia persuasiva. O Gaea permite aos utilizadores efectuarem a reciclagem de objectos virtuais espalhados numa determinada área geográfica, utilizando um dispositivo móvel para localizar e recolher os objectos virtuais que deverão em seguida ser colocados nos respectivos ecopontos virtuais, que ficam disponíveis quando se está perto do expositor público. É também estudado o impacto que este tipo de interacção têm nos comportamentos ambientais dos utilizadores, e se a utilização da persuasão através das redes sociais tem um impacto na popularidade do protótipo.

Os resultados obtidos foram bastante positivos, e podem contribuir consideravelmente para o futuro desenvolvimento de aplicações ubíquas, que apelem à consciência e influenciem um grande número de pessoas a mudar atitudes e comportamentos, em qualquer área de estudo.

Palavras-Chave:

- Dispositivos Móveis
- Tecnologia Persuasiva
- Expositores Públicos
- Interfaces de Utilizadores
- Informação Contextual

Abstract

Through the use of persuasive technology, it is possible to influence the attitudes and behaviors of people in order to lead them to perform actions that, probably, they would not do otherwise. Thus, this technology can be used in several domains such as health, education, business, safety and environment in order to obtain positive changes.

This dissertation aims to bring awareness of the consequences of users' actions on the natural resources of our planet, which are not infinite. Therefore, it was designed and implemented Gaea, a prototype that introduces new forms of interaction between mobile devices and public ambient displays, allied to the use of persuasive technology. Gaea allows users to recycle virtual objects spread on a geographical area, using a mobile device to locate and collect the virtual objects that should be dropped on the correct virtual recycle bins, that are available when near the public ambient display. It is also studied the impact of this type of interaction in the users' environmental behavior, and if the use of persuasion through social networks has an impact on the popularity of the prototype.

The results obtained were very positive, and may give a considerable contribution to the future development of pervasive applications, that increase people awareness and influence a large number of people to change their attitudes and behaviors, regardless the area of study.

Keywords:

- Mobile Devices
- Persuasive Technology
- Public Ambient Displays
- User Interfaces
- Contextual Awareness

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1. Introduction

This dissertation presents and documents the use of persuasion technology through mobile phones and public ambient displays. The concepts of persuasion technology are used with the intent of affecting human attitudes and behaviors towards a better environmental consciousness. The work produced in this dissertation is supported by the DEAP project (Developing Environmental Awareness with Persuasive systems), which includes members of the New University of Lisbon and the University of Évora and is funded by Foundation for Science and Technology (FCT/MCTES).

1.1 Motivation

For years human beings have been consuming Earth resources without even thinking about the consequences of their behaviors. Our planet has limited resources, and in order to preserve them for a long period of time, we need to develop a natural *equilibrium* with the surrounding environment. This *equilibrium* can be achieved in several ways: by recycling the waste we produce, by saving (and also recycling) daily consumptions (like water, energy, gas or diesel) and consequently reducing pollution. However, not all citizens are pro-active in terms of recycling. Even today we still have habits that contribute not only to environmental destruction, but also to negatively influence our economies, since we could save a lot of money if we reduce our daily consumptions.

According to a survey study carried out to assess citizens' receptivity to new technological tools for shaping pro-active environmental behaviors, even those who already have some appropriate behaviors are willing to improve their habits [1]. It was also possible to identify a positive response to persuasive systems that facilitate this change. Therefore, there is room to introduce a new paradigm for environmental awareness, which will help to

motivate citizens to become more responsible towards environment in their everyday life, engaging them in environmental preservation activities. Through the use of new technologies we can more easily change people's behaviors towards environment than we could a few years ago.

To achieve this, the use of new technologies must consider the concepts of persuasive technology. The intention of persuasive technology is to change people's attitudes or behaviors or both through persuasion and social influence (without using coercion or deception) [2] in an interactive way. This technology, related to the area of Human-Computer Interaction, was, until recently, mainly exploited through the use of computers (especially by websites and different types of software). However, since 2006 this situation changed. This was due to the mobile phone.

With the rapid growing of mobile phone market and its technology, it quickly became a all-in-one device with several capabilities, such as MP3 player, Wi-Fi, GPS and camera, that we can no more live without. Mobile phones are probably the most personal and most loved technology in the world, since they are always by our side when we need them, they advise us and entertain us anywhere and anytime we need it [4]. This is why mobile phones represent the leading platform for persuasion.

Keeping this in mind, it is not only possible, but it is also urgent to design mobile applications to motivate and influence people to become more environmentally responsible. Through mobile systems, it is possible to persuade at the right place and at the right time [2]. And since (almost) everyone has a mobile phone, it is also possible to provide games and engage users in social activities that alert citizens to a better environmental consciousness and stimulate them to adapt certain habits.

In order to obtain high success rates, we need to gain the attention of a large group of people, and this can be done by using public ambient displays. These can have a huge importance in the dissemination of the message to convey, due to its unique characteristic: high visibility which draws people's attention. Thus, by applying persuasive technology concepts to mobile phones, and through innovative forms of interaction between these and public ambient displays, we can stimulate citizens to become more aware of our planet

environmental problems, and we can also study how this new kind of persuasion affects people's conscience and everyday life.

1.2 Description and Context

As it has been stated, there are several ways of preventing the waste of potentially useful materials: transforming used materials into new products and reducing the consumption of natural resources (such as water, energy, gas or diesel) and pollution. Either of these factors should be part of people's everyday life, because each of them is too important to be despised. We decided to focus on the first factor in this thesis. In the DEAP project the daily consumptions are discussed in different ways by other thesis and works.

After the analysis of the previously mentioned study [1], we can conclude that there is still a lack of information regarding the recycling of waste materials. It is also stated that more should be made to advertise about recycling, not only on physical places, but also through digital ways, that promote the gains that we get by recycling and the consequences of our actions if we do not do it. In fact there are still many people who are not aware of these issues. As an example, in the United States, only 33.4% of solid waste is either recycled or composted, while 12.6% is burnt in combustion facilities and 54% makes its way into landfills [3]. Some people still act as if planet resources could last forever. Of course this is not true, and if we do not change our behavior, tomorrow it can be too late. These behavior's changes will not produce instant visible results, but they will on the long run. Like voting, people think that by not exercising their right to vote, they will not change a thing, which is wrong, because many people may think the same. Bottom line it is vital that we appeal to the citizens' conscience regarding the possible consequences of their actions, and subtly, take them to change their attitudes and behaviors. By taking this approach, we can inform and bring awareness to people in a way that can lead them to make recycling a part of their everyday life. Furthermore, we could also motivate people to do recycling by giving them some rewards, positive feedback and encourage competitiveness in a way that they would really appreciate.

1.3 Main Contributions

The main contributions of this thesis are:

- *Introduction of innovative forms of interaction between mobile devices and public ambient displays allied to the use of persuasive technology*, which is mainly based on mobile human computer interaction, and how new features and technologies present on the latest smartphones can be applied to detect users' actions and interact with public ambient displays. To this end, it was designed and implemented Gaea, a persuasive location-based multiplayer mobile game, that prompts people to recycle virtual objects on a specific geographic area. The purpose of Gaea is to bring awareness of the consequences of our actions on the natural resources of our planet.
- *The study of the impact of these types of interaction in users' environmental behaviors*, by applying the concepts of persuasive technology and mobile persuasion, in order to stimulate citizens' responsible environmental behavior.
- *Secondarily, the analysis of the persuasion through social networks and its impact in the popularity of the system as well as on the DEAP Project*, so it was possible to know if this concept helped to advertise the environmental awareness.

1.4 Document Organization

The reminder of this thesis is organized as follows:

- *Chapter 2*, describes the state of the art related to the main areas covered by this thesis.
- *Chapter 3*, presents a description of the developed prototype, its objectives and the user and task analysis.
- *Chapter 4*, presents the first prototype developed, and the associated users' test results.

- *Chapter 5*, describes the implementation of the second prototype, as well as the corresponding usability evaluation and the impact tests.
- *Chapter 6*, describes the conclusions and a discussion of future work.

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2. Related Work

This chapter presents a summary of the state of the art of the main areas covered by this thesis. These areas are Persuasive Technology, Mobile Human Computer Interaction, Interaction with Public Ambient Displays and Environmental Awareness.

2.1 Persuasive Technology

Persuasive technology is the general class of technologies that purposefully applies psychological principles of persuasion (such as principles of credibility, trust, reciprocity or authority) to interactive media, aiming at changing users' attitudes and behavior [5]. The term captology was coined in 1996 by BJ Fogg, and is derived from computers as persuasive technology [2]. It focuses on the study of Human Computer Interaction, investigating how people are motivated or persuaded when interacting with computer devices rather than through them (as the computer-mediated communication, which consists on any communicative transaction that occurs through the use of two or more networked computers [6]). Figure 1 presents this situation.

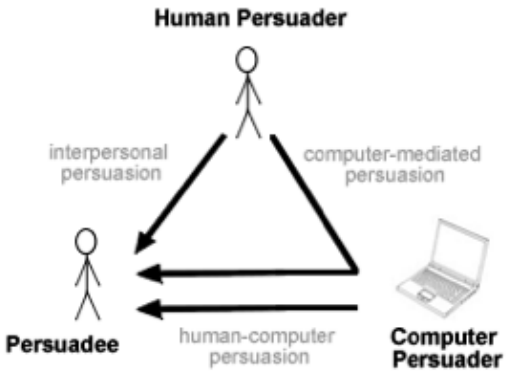

Fig. 1 - Persuasion types (from [57])

Thus, captology focuses on planned persuasive effects of technology, intended by the designers of the products, not on side or unintended effects which can be misleading of the product true intent. That relates to another point about captology: endogenous and exogenous intent. The first one (focused by captology) is the persuasive intent that is designed into a computing product, while the second one is the intention adopted by the users, which the designers had not foreseen. Finally, the attitude and behavior changes that result from the application of the captology concepts can be made in a macro level (the overall persuasive intent of a product, where motivation and persuasion are the main reasons of its existence) or in a micro level (small persuasive elements that help achieve a different goal). Next, figure 2 describes how computers and persuasion overlap, creating captology.

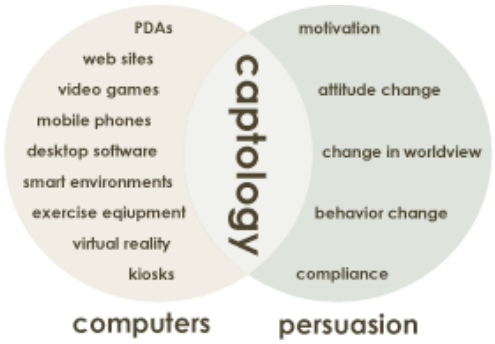

Fig. 2 - Captology: how computers and persuasion overlap

2.1.1 Computers as Persuasive Agents

In order to explain the roles that computers can play as persuasive agents, a framework known as functional triad was defined [2]. It shows that interactive and computing technologies have three roles: tool, media and social actor, which help capturing how people use or respond to any computer device. Figure 3 shows an overview of those roles.

Fig. 3 - Functional triad of persuasive technology

Computers are essential tools that help fulfill our needs. They help us to easily accomplish tasks, in a simply and efficient way, that would otherwise take much longer. Therefore, when acting as tools, computers can make a target behavior easier to achieve, influence and motivate people in specific ways, leading them through processes and performing measurements or calculations that motivate them to reach their goals. Some usual examples include motivating people: to have a healthy life [26], to do exercise [27], to buy more products (through a recommendation system based on user interests and previous purchases, very popular in online stores like Amazon) or to reduce energy consumption [28].

A persuasive technology tool is an interactive product designed to change attitudes or behaviors, or both, by making desired outcomes easier to achieve [2]. Fogg outlines seven main tools for persuasive technology [2]: Reduction, Tunneling, Tailoring, Suggestion, Self-monitoring, Surveillance and Conditioning. These can be applied into a product separately or by combining two or more types, in order to achieve a specific goal. Next, each of these technology tools is detailed and explained how they can be applied to a product.

- *Reduction*, the basic concept of this technology is to make the complex, simple. For example, if a user wants to install a program in his/her computer, and there are two similar programs that satisfy his/her needs, with only one difference: the program A needs to be installed through a console (the user needs to type some commands), while program B has a wizard installation, which simplifies the installation process. By making the complex, simple, the user is persuaded to download program B instead, since it reduces complex behavior to simple tasks increasing the benefit/cost

ratio of the behavior and influencing user to perform the behavior (principle of reduction [2]), which ends influencing the user in his/her ultimate decision. Reduction technologies may also help increasing a user's self-efficacy, or the user's belief in his/her capabilities to perform a specific task. In turn, that can help the user to develop a more positive attitude towards the behavior, trying harder to adopt the behavior and performing it more frequently [7].

- *Tunneling*, if a user does not know how to complete a particular goal, it will probably discourage him/her to complete it. The purpose of tunneling is to guide users, through a process or experience, which provides opportunities to persuade along the way (principle of tunneling [2]). An example of this tool are the personal trainers hired to help people stay in shape, while the wizard installation is an example of both reduction and tunneling persuasive technology tools. From a design perspective, tunneling is very effective, because it allows to control how the product is used by the users. From a user perspective, tunneling is effective, because people tend to be committed to a task that otherwise would not and facilitates users' tasks.
- *Tailoring*, this persuasive tool is very useful in order to make a personal product by applying persuasion through customization. This way, the information provided will be more persuasive if it is tailored to the user's needs, interests or other factors relevant to him/her (principle of tailoring [2]). In other words, it is more simple and grateful for a user to access a specific information that he/she is interested in than to browse through a large volume of data, looking for what he/she wants, or even to access information that he/she does not have an interest in. Also, the customized information can be used to persuade a large number of people scattered through different education levels, age groups and social status, in order to spread the same message but with different kinds of information.
- *Suggestion*, as the name implies, this technology is about intervening at the right time with suggestions for specific actions. This way, a computing technology will have greater persuasive power if it offers suggestions at the right moments (principle of suggestion [2]). An evident example is the concept of mobile persuasion (used by

mobile devices and addressed later) which uses the concept of *kairos* (present the message on the opportune moment). Suggestion technology can also be applied to a large number of people, by proposing specific actions in a crowded space (like restaurant's billboards indicating that it is located just 3 or 4 minutes away).

- *Self-monitoring*, this technology allows people to monitor themselves in order to change their attitudes or behaviors to achieve a particular goal. By giving users data about their performance or status, it eliminates the tedium that they would have if they would need to make it by themselves (principle of self-monitoring [2]). Furthermore, this technology gives users easy access to data about themselves, allowing them to modify their behaviors according to it. A very popular example are the heart rate monitors which allow people to modify their exercise levels according to their heart rate, and pedometers which are very popular among joggers.
- *Surveillance*, it must not be confused with the previous technology tool. While self-monitoring allows users to access information about themselves, surveillance allows them to access information about others. The key of this technology tool is observation, which increases the likelihood of achieving a desired outcome (principle of surveillance [2]). This is the most common persuasive technology tool in today's marketplace, because there is surveillance for everything: to observe restaurant's cooks and employees or to track how employees use the Internet. By observing people's actions it is possible to reward them if they complete specific tasks that match the observer's expectation [8]. Also, when people know that they are being observed, they tend to have compatible behaviors with the expected ones.
- *Conditioning*, by giving positive reinforcement to shape complex behaviors, it is possible to transform occasional attitudes into habits (principle of conditioning [2]). This technology reinforces target behaviors like making a specific action in a daily basis (i.e. go to a website or take care of plants) by continuously rewarding users (recently digital rewards have been very popular), which will ultimately result in a daily routine for the user.

Choosing the right persuasive technology tool for the product is not easy, because there must be a natural synergy between the proposed task and the intended persuasive technology tools, which otherwise may lead to unintended effects.

When computers act as media, persuasive effects can be achieved by allowing people to explore cause-and-effect relationships, providing people with new and different experiences that help them to get motivated and helping people rehearse a behavior.

By using computers to create simulations of the real world, it is possible to imitate experiences and create non-real worlds that could be felt as real. Three classes of computer-based simulations can be considered: cause-and-effect, environments and objects. Next, each one of these simulations classes is detailed and it is also explained how they can offer an insight as sensory media.

- *Cause-and-effect*, refers to the philosophical concept of causality, which is a relationship between an event (cause) and a second event (the effect) that is a consequence of the first. In computing technology this is associated with the input and output terms, where the outputs are shown on a display as a consequence of input devices usage, like a keyboard or a mouse. By using simulations users are able to explore and experiment their actions' consequences in a safe environment, where they can see the link between cause and effect clearly and immediately. This can persuade users to change their attitudes or behaviors (principle of cause and effect [2]). Some popular applications that adopt this type of simulation are games and information systems that help people to learn about specific topics.
- *Environment*, this class is often based on virtual environments that provide immersive surroundings, creating artificial worlds. By providing a motivating simulated environment where users can rehearse a behavior, users are enabled to change their attitudes and behavior in the real world (principle of virtual rehearsal [2]). These simulations can also give virtual rewards in order to influence people to perform target behaviors more frequently and effectively (principle of virtual

rewards [2]). Some examples of this type of simulation are VR bikes and VR therapies that help people to overcome phobias [2].

- *Objects*, are the opposite of environment simulations, because they are implemented in a real world setting. This makes the simulation less dependent on imagination, fitting into the context of a person's everyday life, and making clear the impact of certain attitudes and behaviors. Therefore, this kind of simulation can enhance the impact of certain behaviors and motivate behavior and attitudes changes (principle of simulations in real-world contexts [2]). One example of this simulation class is the Neon Drunk Driving Simulator (where the user drives a real car in normal conditions and next he/she drives it in "drunk mode") that provides a sobering experience of the dangers of driving drunk [2].

As it has been stated, there are several ways for computers to play as media or simulations, but all of them use experience as a basis to persuade the user.

Computers are usually treated as a living being, because people get very attached to them, creating a special relationship with the computer device. Thus, computers can take advantage of this relationship to apply the same persuasion techniques that humans use to influence others, by providing users with positive feedback, modeling a target behavior or attitude and providing social support.

Computers act as persuasive social actors, by giving users a range of social cues in order to extract social responses from them. Fogg lists five types of social cues (physical, psychological, language, social dynamics and social roles) which are detailed below:

- *Physical*, refers to computing products that can convey physical cues like face, eyes or body which enables them to transmit a sense of social presence. The use of visually attractive elements in a computer product has a higher chance to have success and to persuade a user than a product that does not (principle of

attractiveness [2]). For example, games on the Facebook Platform, use attractive art elements to catch people's attention.

- *Psychological*, by psychological it means that software product can lead people to think that they have their own will, emotions, motivations, interests and a personality. Obviously this is not the case, but the intent is to make the product a friendly figure that the user can have a nice time with. Keeping that in mind, it is easier to persuade people to use software products that are similar to themselves than others that do not seem similar (principle of similarity [2]). An example of that are the different websites made for different ages, where the colors and the structure are different for each target user.
- *Language*, the way computer products "talk" with users can lead them to unexpected actions that have not been foreseen. Sometimes, the way language is used is enough to make us do a specific action. This concept is also related to the principle of praise [2], which states that by offering a praise, via a digital way, computing technology can lead users to be more open towards persuasion.
- *Social dynamics*, refers to the unwritten rules for interacting with others. This tends to affect users' feelings and actions, specially by applying reciprocity, which means that people feel the need to reciprocate when computing technology has done them a favor (principle of reciprocity [2]).
- *Social roles*, computers can have authority roles that mimic human ones (like a police man, a judge or a referee). In general, people expect authorities to lead them, make suggestions, provide information and aid them in a particular process. By assuming roles of authority, computers have enhanced powers of persuasion (principle of authority [2]). An example of this, are the characters created by books, websites and software, that aid people achieving a goal.

All of those social roles are important in order to appeal or persuade the user to make a particular action, and should not be forgotten when designing a computer product.

2.1.2 Mobile Persuasion

As it was previously stated, the *just-in-time* ability (intervene at the right moments) has a great persuasive power. The most powerful way to do this is if there is a way to give us suggestions anytime and everywhere we go. This is when mobile phones come in.

Over the last years, there was a huge growth in the mobile market, with new technologies and features being added to mobile phones. Nowadays, there are mobile phones that have GPS, compass, MP3 player, touchscreen interface, accelerometer or gyroscope, something that could not be imagined some years ago. As a consequence, we have become more attached to mobile phones, and today, most of us cannot leave home without it. This makes mobile phone an excellent persuasion tool, which can very well be the most important platform for persuasion in the next years, for three reasons: people love mobile phones, they are always with them and as mentioned, they have a wide range of features [9]. Fogg proposed three metaphors to represent these reasons: heart, wristwatch and magic wand [9].

By heart, he means that we love our mobile phones and that we cannot live without them. They spend more time with us than any other person or object in our everyday's life. Due to this, the mobile-human relationship is the most personal, intensive and lasting of all relationships. Thus, to explore that relationship, it is necessary to give people the same positive feelings (principle of mobile marriage [2]), so they can feel trust and competence, in order to try new behaviors.

The wristwatch metaphor is directly connected to the principle of *kairos* (mobile devices are ideally suited to offer suggestions at opportune moments to increase the potential to persuade) [2], which attempts to persuade a person at the right time and at the right place. By always being with us (like a wristwatch), the mobile phone can be used to persuade us to take decisions that depend on contextual information. For example, if a notification alerts a user, when he is about to get home, use the stairs instead of using the elevator in order to save energy and do exercise, he will probably take the stairs. That is one persuasive role that mobile phones can assume: the role of a coach, which tracks our context and reacts according to it. There are two others: concierge and court jester. In the first one, the mobile phone

assumes the role of adviser, by giving us tips and guidance when we need (i.e. looking for restaurants near our location). In the second one, the mobile phone allows us to have a good time with entertainment applications and games, that amuse us and provide us fun in boring moments. During this stage, the mobile phone can persuade us to take certain actions, because it is easier to convince people if they are in a good mood.

The magic wand metaphor refers to the capabilities that mobile phones can have. In the smallest communication device, we can access data on the Web, track our location through GPS or ask for directions by using GPS and compass. All of those can be accessed in a simple and easy manner that allow mobile applications to have a great opportunity and potential to persuade (principle of convenience and principle of mobile simplicity [2]), that can be harness to change human behavior, in a way that we have not seen before.

One example that demonstrate that mobile phones are excellent persuasion tools is the use of mobile phones to support children's literacy learning [10]. In this paper it was introduced a mobile application that encouraged parents to engage in daily literacy learning activities with their children, through the use of text and audio messages for parents, and audio and video messages for children, based on Sesame Street series. Text messages were sent to participants' mobile phones prompting parents to access audio and videos messages for their daily activities. These messages contained letters of the alphabet that would suggest real-world literacy activities, for example while parents and children were in the supermarket, they would look for fruits and vegetables that begin with a specific letter. Then, children would access audio messages from Sesame Street's Elmo, which contained more information and a video about the letter in question. At the end of the week, if participants accessed the application three or four times, then they would end the experiment period with access to the 26 letters in the alphabet, as well to Sesame Street video clips on a weekly basis (a clear example of the implementation of the principle of virtual rewards). The study also demonstrated an enormous enthusiasm about the accessibility of the mobile device and content, which allowed users to access information everywhere they wanted.

Furthermore, there are also examples that promote pro-environmental behaviors, like the PerCues [58] and the UbiGreen Transportation Display [59]. PerCues is a persuasive system

developed by Reitberger et al, intended to reduce pollution through the use of public transportation. If people choose to use the bus instead of the car, the system informs the user, through a mobile phone, about the consequences of their own choice. The information about all the users that individually had the same decision is gathered and the group of persons who had the same choice know from that moment on the impacts of individual and group action. Using individual actions to inform about group state can be a good form of persuasion because people relate to a more significant change with a simple action. UbiGreen Transportation Display is a mobile application prototype that semi-automatically senses and reveals information about transportation behavior, aiming at engaging users in the goal of increasing green transportation and reducing pollution. It requires users to carry a Mobile Sensing Platform that contains ten sensors including a 3-axis accelerometer, a barometer, and infrared light sensor. Its onboard algorithms are able to accurately differentiate sitting, standing, walking, running and cycling activities. It is a single user application that does not explore persuasion through social networks nor public ambient displays.

There are more examples that apply these roles and concepts, in several areas of society, in order to promote sexual health [11], energy reduction [12], health assistant [13] and more. At the end, whatever may be the area of the application, mobile persuasion helps enhancing the users' quality of life, by aiding them in everyday's tasks and social activities.

2.1.3 Persuasion through Social Networks

The concept of social networks exploded with Web 2.0. Web 2.0 allowed people to share information in an interactive way via the World Wide Web. By using Web 2.0 technologies, social networks created services that enable people to establish social links with their friends, according to the interests that they could share. Since a lot of people spend so much time logged in social networking websites, social networks evolved and today they have several integrated services such as games, entertainment and questionnaires, that persuade millions of users on a daily basis and lead them to adopt the intended behaviors and attitudes.

Facebook is a fine example of how this kind of persuasion can succeed. In order to explain it, Liu [14] presented a model that decomposes Facebook's persuasion into community elements and persuasive factors. There are three fundamental online community elements for user interaction: content (notes or photos), community of users who share common interests (groups or friends) and activity of users to join or interact (events or application visiting). Figure 4 describes the connections between users and those elements.

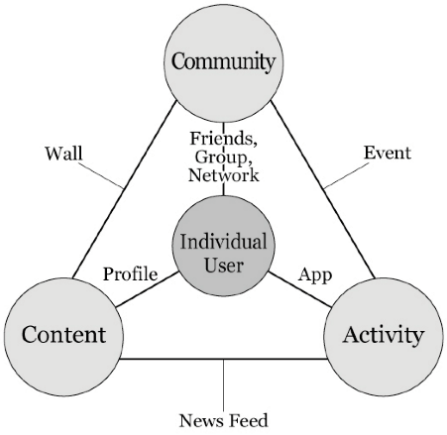

Fig. 4 - Persuasive model of the Triangle User Lock

The links between the elements and the user represent the features that Facebook uses in order to enhance self-perception (with simple clicks and data inputs makes it possible to create an incentive to create content) and social capital (by connecting different elements into a seamless network). At the end, users are being tied in Facebook with increasingly self-knowledge, as they are also integrated into several social networks with great social capitals. It also 'triggers strong need to belong and social validation as powerful persuasive factors to motivate user response and engagement' [14].

In 2007, Facebook launched Facebook Platform, that allowed developers to create applications (mainly games) for the millions of people registered in the network. This started a new phenomenon, which Fogg calls "Mass Interpersonal Persuasion" (MIP) [4]. MIP brings together the power of interpersonal persuasion with the reach of mass media, by creating applications that allow people to interact and cooperate on a non-personal level,

allowing them to reach a mass number of people. MIP has six components: persuasive experience (an experience that is created to change attitudes and behaviors), automated structure (digital technology that structures the persuasive experience), social distribution (persuasive experience is shared from one friend to another), rapid cycle (persuasive experience can be distributed quickly from one person to another), huge social graph (persuasive experience can potentially reach millions of people connected through social ties or structured interactions) and measured impact (the effect of the persuasive experience is observable by users and creators). An example of the application of those components are the messages generated by games like FarmVille, which apply persuasive strategies in order to persuade people to help their friends.

Social networks like Facebook, are excellent tools of persuasion. In order to exploit their characteristics, it is necessary to understand how they work and what persuades people to use them on a daily basis.

2.2 Mobile Human Computer Interaction

The Mobile Human Computer Interaction (MHCI) focuses on studying the relation and interaction between users and mobile devices. This is a particular area of Human Computer Interaction (HCI), that requires the study of specific features and the overcome of additional challenges. Of course that there are HCI design rules and concepts that also apply to MHCI, like Schneiderman's Eight Golden Rules [15] and Norman's Seven Principles [16], but they need to be adapted or extended to mobile devices. For example, one of the areas that is extensively studied in MHCI, is the visualization of information. Due to displays restrictions (small size and low resolution), mobile developers must design applications that not only adapt to those displays, but also combine usability and accessibility on the application's interfaces. On the other hand, MHCI also has advantages over traditional HCI, due to features like portability and wide range of technologies, which enable users to access contextual information, through the use of technologies integrated in the mobile devices.

These are two examples of how mobile devices affect the design of mobile applications and interfaces.

Therefore, when developing mobile applications, it is necessary to consider design issues that are specific to the mobile devices, because of the heterogeneity of this type of technology, as different dimensions, hardware, input controls and techniques, connectivity and software support.

2.2.1 Mobile Interface Design

While designing mobile applications, there are some common problems that surface, which are normally related to three areas: screen space, interaction mechanisms and design at large [18]. Nilsson identified a small number of sub-areas problem within these three main areas, and within each of these sub-areas, a number of problems were found (26 in total) [18]. The next table (table 1) sums up some of these problems (15 to be exact).

Main Problem Area	Sub-Area	Individual Problems / UI Design Patterns
Screen Space	Screen space in general	Presenting elements in lists
		Principles and mechanisms for grouping information
		Mechanisms for packing information
	Flexible user interfaces	Handling dialogs when software keyboard is shown/hidden
		Supporting switching between portrait and landscape mode
		UIs that should run on equipment with different screen size
Interaction Mechanisms	Handling input	Mechanisms for entering text
		Mechanisms for entering numerical data
		Multimodal input
	Not using the stylus	Interacting with applications without using stylus
		Retrieving data from a database without using keyboard
Design at Large	Guidelines	Standard features in an automatically generated prototype
		Combining branding, aesthetics, and screen space

Main Problem Area	Sub-Area	Individual Problems / UI Design Patterns
	"Difficult to understand"	User interaction during synchronization
		User interaction during long-lasting operations

Table 1 - Table based on Nilsson's study [17]

The patterns collection (all the 26) was presented in the tutorials at the HCI International Conference 2007 and at the IASTED HCI Conference 2008. At these tutorials, it was conducted a survey which identified that the most popular problems were mechanisms for entering text, multimodal input, packing and grouping information, showing/hiding software keyboard and user interaction during long-lasting operations [18]. These interface problems were considered to be relevant to mobile interface design, and therefore, should be addressed when developing mobile applications, in order to promote interface usability and functionality.

The design of mobile interfaces that take advantage of the human visual capabilities in order to improve data understanding and faster information perception, are more likely to succeed than those that do not. People are used to rely on visualizations in order to better understand the interface that is displayed so they can take quicker decisions. For example, through mail applications, we can easily find how many mails we have, how many have arrived or check our to-do list and notes. A eyes-free interface can be the most convenient and effective for simple tasks, by applying design principles like KISS (keep it simple, stupid). With this in mind, Chittaro defined [19] a disciplined process for the design of mobile visualization:

- *Mapping*, meaning we should visually encode information in a proper and right way. Chitarro defines two principles: a precise mapping between data objects (and their relations) and visual objects (and their relations) as icons, colors, positions or size, must be explicitly defined and consistently applied through the application. Conceptually important aspects must be perceptively important, and conceptually

unimportant aspects must be perceptively unimportant. As an example, if we want to know which restaurants are near our location, we look for icons that resemble food (like a knife and fork).

- *Selection*, refers to data that is relevant to a specific task. In general, it is possible to apply a visual feature which makes it easier to identify the different features. Example: if we want to know the quality of a given restaurant, we can add a bar (the more green it is, the better is the quality) to the restaurant icon near it.
- *Presentation*, a recurring problem when developing mobile applications: there is too much data for too little display area. There are some solutions for this problem: scrolling (thanks to the touchscreen technology, it has become the most popular solution, although we are stuck in one view), abstraction (provides context, but hides details), switching among multiple screens (it can generate navigation problems, due to loss of track of views), overview and detail approaches (provides two separated views simultaneously: one for context, one for details) and focus and context approaches (which provides context and detail information simultaneously, but without separating the two views).
- *Interactivity*, through interaction we can explore and rearrange information visualization. In context aware applications, the data is being continuously updated, and therefore, visualization needs to be updated in real-time as users perform actions. In order to allow that, the features presented in these kind of applications must be implemented to enable visual dynamic queries.
- *Human Factors*, when developing an application it is indispensable to take into account human perceptual and cognitive abilities. Users must be able to quickly, easily and correctly recognize and interpret displayed data. So, it is important to analyze factors like brightness, contrast or colors. For example, visual resolution of fine detail is poor for blue (that is why it is suggested not to use blue for small details). There are fewer blue receptors than green or red in the human retina, and none in the central fovea (the point of highest acuity).

- *Evaluation*, user testing is an important process when designing an interface. Thus, in order to guarantee the effectiveness of the designed visualizations, applications need to be shown with proper tests on humans. But, evaluating interfaces on phone simulators is not enough: those tests need to be made on the device, due to their characteristics (such as dimension, reduced display or input).

2.2.2 Context Awareness

The ability of discovering and reacting to changes in the environment and to users' actions, is a key feature of mobile devices: it provides a better users' experience by giving access to services that are dependent on our surrounding context. While developing a context-aware application there are two concepts that must be addressed: contextual sensing (refers to the detection of contextual information) and contextual adaptation (refers to the capability of the application to adapt its behavior by using contextual information). Therefore, it is necessary to identify the relevant context, integrate mechanisms for acquisitions of the relevant context and integrate context-aware behaviors. Identifying the relevant context can be done through the use of sensors integrated in today's mobile phones, such as light sensors, GPS and accelerometers, and by using different techniques like triangulation, proximity or scene analysis, while context-aware behaviors (i.e. changing the presented information) are established by the data received from sensors.

Schmidt [20] discusses how sharing context in communication applications can improve the user experience. He defines three aspects for which context is key for efficient communication: coding in context (coding and representation chosen to fit the context), transport of the message (appropriate media chosen for the current context) and decoding of the message (it is necessary to use context information to interpret the message). It is also indispensable to rethink about user interface options when designing context-aware applications, whether these are output or input options. Regarding output options it is necessary to make use of the context, adjust media quality, adapt media usages, adapt content and visual presentation and timing (send the right notifications at the right time). Regarding

input options it is necessary to facilitate data input by using context information, allow different ways of input, provide context-dependent defaults and optimize input space to current context. It is, then, necessary to take context of usage into account when designing applications. This can be done at design time (design for a certain context) and at run time (recognizing context and act in accordance to it). An interesting example of a context-aware application, is the context phonebook [21], which contains contextual information, such as users' location and status additionally to the phone number. This way, a user can know if the person he/she wants to call is available or not (can be on a meeting or driving).

In the end, user's perception is determinant to allow users to have smart behaviors in a context-aware application.

2.3 Interaction with Public Ambient Displays

Through the use of public ambient displays it is possible to gain the attention of a large group of people, which is very important to spread the message we want to convey. There are several factors that may affect not only the user but also the audience's experience, such as the type of interaction used to interact with the display, its location, the importance of the information displayed as well as the structure of how the information is displayed. Even if the audience cannot interact with the display right away, it is important to encourage members of the audience to talk to each other in ways they feel comfortable with, which will help to promote discussion on the topics mentioned on the public ambient display.

So, by creating applications for public ambient displays that are designed not only for users but also for the audience, it is possible to spread the message that we want to convey more quickly, which will ultimately result in applications becoming more popular.

2.3.1 *Overt* and *Covert* Interaction

It is possible to classify two types of interaction with public ambient displays: *overt* interaction and *covert* interaction [22]. *Overt* interaction is a consequence of using devices

like stylus, mouse or keyboard to directly interact with a display. In this case users' actions can be watched by the audience, which can sometimes cause social embarrassment, and so, discourage interaction with the display. *Covert* interaction refers to the interaction between the display and mobile phones or implicit physical movement. *Covert* interaction provides users with more privacy and confidence during their interaction process, but does little to inform about interaction with the display.

Although *overt* interaction does not have the same kind of features presented on mobile phones to detect users' actions, some approaches explored the use of sensing technology to overcome these limitations and induce behavior changes. Smart Bins [60] is an augmented recycle bin developed to increase children's awareness regarding recycling activities. It was designed as an educational game intended to ease the learning process while motivating children to adopt more responsible attitudes towards the environment. It was not intended for mobile use, but it exploited, with success, the use of a public ambient display.

Kaviani et al [22] study shows that *covert* interaction reduces the chance of learning by watching others playing, and that learning happens mainly in groups where members know each other. Therefore, to enable *covert* interaction and allow learning at the same time, it is necessary to put a great emphasis on the information part, in order for the audience to learn individually (which allows learning by watching amongst strangers). Thus, in their study, Kaviani et al devoted great emphasis (both on the mobile device and public ambient display) to instructions on how to interact. Also font sizes were chosen according to the level of information, not only due to the importance of information, but also to bring interested people closer to the display. Information display was placed in such a way that the passing audience would first observe the information display, decode the information shown on it, and then get to observe the actual application. Based on correct input, the study of the results shows that the learning ability goal reached a 95% success rate.

As it was demonstrated, half the battle in designing an interactive public display (even for interacting with mobile devices) depends on inviting and maintaining interaction even after the novelty factor wears off [23].

2.3.2 Encouraging Interaction and Socializing around Public Ambient Displays

Either we are creating *covert* or *overt* interactions, a common goal of these interactions is to encourage people to interact and socialize around a public ambient display. On their study [29], Rogers and Brignull described a system that was placed in a real-life social gathering, which was intended to encourage socializing and interaction. The goal was to provide a shared virtual space which people could add their opinions to, making it a collective trace of social commentary over time, which could provide a stimulus to initiate conversations between people in the same physical space. On this study, they were primarily concerned about three topics: the importance of providing a theme to structure the interactions, the physical location to place the display and the chaining of comments and opinions on the application over time.

Regarding the first topic, on an initial phase, results of the study show that the displayed information must draw people's attention (typically by making questions), motivating them to exchange opinions. Also, the application must be designed to show information for limited time, with new information appearing every minutes or so, in order to keep the display "fresh", maintaining people near the display as also drawing more people to it (by watching others).

The physical location of the display must be on a social setting where people pass by a few times each day. For example, initially a physical whiteboard was placed next to a coffee machine, and later it was placed in a book launch party setting in a raised platform next to the bar, making the text legible from approximately 5 meters away, and also visible to those at the front of the room. Both of these settings showed to be successful. Furthermore, during the party setting, a "honey-pot" effect emerged, where a physical space around the system became "marked", drawing in a crowd, which in turn created a certain kind of social affordance, where it became socially acceptable to spark up conversations with others. On another but also similar setting (welcome party for postgraduates entering a school at a university), Rogers and Brignull [30] also mention that people became aware of the large display through peripheral monitoring of their surrounding environment, noticing some

ongoing “public” activities in the space around it. For example, one participant said: “I didn’t see people using it at first, but I did see people standing around it so I stood beside and watched it for a while”. If their curiosity is sufficiently aroused, people will move from a peripheral awareness activity space (where they are typically eating, drinking or socializing) to a focal awareness activity space (where they are engaging in socializing activities associated with the display) [30].

Finally, regarding the chaining of comments and opinions on the application over time, this study [29] shows that about 40 people typed in comments to the system and many more stood around observing what was happening. Moreover, many people that observed how easy and fun it was to take part, also wanted to participate on the activity. It was found that many of the comments and opinions were humorous (62%), while the rate of participation over time increased as new questions were brought up by the system.

At the end, Rogers and Brignull study [29] suggest that the design of technology-mediated ice-breakers need to: have a lightweight interface (which is simple and quick to use), be able to learn vicariously (so that people can simply walk up and use it, having watched others do the same) and be clear to the person that the interaction with the system will be a low commitment activity which will be quick and enjoyable.

2.4 Environmental Awareness

Environmental awareness along with environmental education, play a major role in encouraging and enhancing people's participation in activities regarding protection, and conservation of our environment, which is essential for achieving the *equilibrium* mentioned in the introduction. By developing applications that promote these topics, it is possible to appeal to citizens’ conscience in order to encourage pro-environmental behaviors and to educate users by changing attitudes and behaviors.

2.4.1 The Need for Pro-Environmental Behaviors

The Living Planet Report 2008 [24] shows that we are consuming Earth resources too fast. Reckless consumption is depleting Earth's natural capital up to a point where we are endangering our future prosperity. We are demanding too much from our planet's living resources, and Humanity's Ecological Footprint exceeds the planet's regenerative capacity in about 30%, as figure 5 demonstrates.

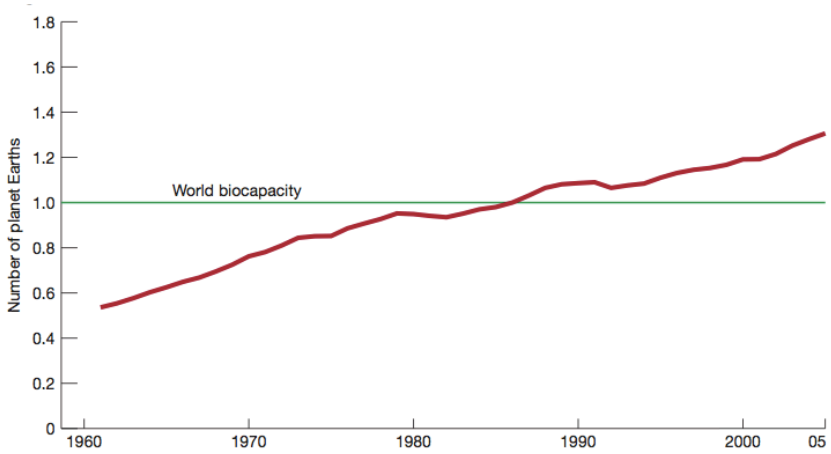

Fig. 5 - Humanity's Ecological Footprint

If our demands on the planet continue at the same rate, by mid-2030s we will need the equivalent of two planets to maintain our lifestyles. Of course this is not possible, and we have to do something about it. If we do not balance our consumption with the Earth's capacity we risk doing irreversible damages. The actions to prevent it, must be made at a global level, where the majority of human beings participate to achieve a single goal: save, reuse and recycle Earth resources.

2.4.2 Promoting Pro-Environmental Behaviors

As it was presented in persuasive technology section, changing behaviors is not an easy task. It follows a group of principles, concepts and design decisions that need to be applied to

different types of audience. To address these issues, an analysis [25] was conducted on how to promote pro-environmental behaviors. That analysis identifies the following key aspects:

- *Behaviors are complex and non-linear*, behaviors can be influenced by a set of aspects (external and internal) that make them difficult to foresee.
- *Different audiences behave differently*, it is necessary to keep in mind that different audiences require different types of approaches.
- *Feedback is vital to driving and sustaining change*, behavior changes should be viewed as an ongoing process. It should be vital for the designers to learn with the audiences, and to know what worked and what it did not. It is also important to collect data in an efficiently and easy way (i.e. application logs).
- *Individuals have the potential to act as "change champions"*, individuals are vital to delivering pro-environmental changes, not just for themselves but also within networks and communities (i.e. social networks) as agents to carry the message that we want to convey.
- *Action needs to be taken now*, as it was stated, pro-environmental behaviors need to be acquired today in order to address the pressing environmental problems. Change takes time, and measures need to be put into place now to influence societal change and respond to environmental pressures [25].

Furthermore, Steg and Vleg [61] stated that environmental quality strongly depends on human behavior patterns and that individuals can contribute significantly to achieving long-term environmental sustainability by adopting pro-environmental behavior patterns. They proposed a general framework for understanding and promoting pro-environmental behavior, comprising: (1) identification of the behavior to be changed, (2) examination of the main factors underlying this behavior, (3) design and application of interventions to change behavior to reduce environmental impact, and (4) evaluation of the effects of interventions.

3. Design Process

This chapter presents the iterative design process of Gaea, a prototype that introduces innovative forms of interaction between mobile devices and public ambient displays, allied to the use of persuasive technology. The system allows to instruct, inform and persuade the users to perform a correct recycling of their wastes. This chapter starts by describing the system and its objectives, and then the design methodology is explained followed by the presentation of the user and task analysis.

3.1 Description and Objectives

As it was described in section 1.1, it was important that the solution presented in this thesis had the following topics as objectives: to inform the users about the consequences and gains of recycling, to advertise it in digital ways, to reward users in a way they could really appreciate and to encourage competitiveness and provide users with entertainment. All these topics were constantly considered during the development of the implemented system.

The envisioned system is as follows: imagine a garden, a natural park or any other open space with waste scattered all over it. However, instead of real waste, it is virtual waste. It does not exist, except if we have a mobile phone to locate it, which provides a map to show the locations of those virtual objects. These objects are addressed to geographical coordinates (generated by a server), and in order to pick them up, the user has to go to the location where they are. Once near one of these objects, the user must grab it (by interacting with the application) and bring it to the right virtual recycle bin which becomes available on the mobile device, when the user is back near the public ambient display (which is also associated to a geographic coordinate) and facing it. In order to motivate the user to continue his task, he is rewarded with points and at the same time he is also learning how to do a

correct recycling, as well as being informed about recycling facts. However, if he misplaces an object, he is informed by the application so as not to make the same mistake the next time, and consequently does not receive any points. The public ambient display monitors all the information going back and forth between the server and the mobile devices connected to it. The public ambient display also shows a local map with the virtual objects and players' locations (so it is possible to know what is going on by the audience), feedback given to the users about their actions (if they dropped the object on the correct recycle bin), players' game ranking, instructions and other data related to the game activity. Also, in order to urge the users to recycle and to inform them about the status of our planet resources, every time a user drops an object into a recycle bin he receives specific information about that object in the context of the planet resources, in his mobile device. If the user marks it as read, he is rewarded with extra points. After the play area is clean, a quiz appears on the public ambient display with questions about the information that was previously presented to the users. The user is then prompted to use the mobile device to answer those questions, by selecting one of three possible answers. The audience can also follow the quiz.

This is the basic concept applied to only one user. Now, let us imagine it in a multi-user scenario where each user competes to recycle the largest number of objects and to achieve the best possible score. Even better, imagine several users organized by teams, where some teams are in charge of picking up paper, others are in charged of plastic/metal and others of glass. It becomes a collaborative/competitive social activity that persuades a group of people to do a single action together. Obviously they are not directly helping the environment, because they are collecting virtual waste instead of real waste, but they are learning better ways of recycling and are being informed about the consequences and gains of their actions through this activity. It also stimulates social and collaborative activities and may influence people to have the same kind of behavior in their daily life.

So, considering the objectives previously mentioned, those were achieved in the following ways:

- *Information about the consequences and gains of recycling*: as mentioned, the public ambient display, and the mobile devices, provide the users with environmental information, as well as the information regarding the status of the activity. This information needs to be displayed on both devices, because on one hand the audience needs to be able to read it (in order to also learn while not playing), and on the other hand, the only way to know if the players read it, is by displaying the information on their mobile devices.
- *Digital ways of advertising*: an interesting way to reach a mass number of persons, is by using social networks. There are millions of people connected through social networks on the Web. The most popular social networking site in several English-speaking countries, Facebook, has 500 million users worldwide [56], and millions of people use it on a daily basis. As mentioned in [4], the mass interpersonal persuasion emerged in 2007 and will change the future of persuasion, since it reaches masses of people in a very fast way. This became possible with the launch of Facebook Platform, which allows developers to use Facebook API and their tools to create popular applications like FarmVille, Mafia Wars, Café World, among others. Thus, in order to advertise our solution, we used Facebook Connect so that users could login in the mobile application with their Facebook account, and easily share their experience and accomplishments through this social network, by posting them on their Facebook Wall. This allows users to spread the word in an easy and powerful way that would be impossible without the use of social networks.
- *Reward users with something that they would appreciate*: sometimes if we do not reward (physically or virtually) users, they tend not to use a service. This is why, it is important to give something that users could appreciate and be proud of having it. Therefore, by using Facebook, it is possible to give them items, virtual money and achievements that users could not get anywhere else. These rewards are a part of a game that we have planned in the scope of the DEAP project through the Facebook API and tools (which is to be developed as another master thesis). The idea is to persuade the user to take part in this activity, because it will be the only way of

getting the rewards that he wanted/needed on the Facebook game. But we must never forget that, at the end of the day, the most important is the information given to the users about environmental issues and how they can contribute to preserve the environment.

- *Competitiveness and entertainment*: through the use of scores and statistics it is possible to promote competitiveness between users, in order to motivate them to reach their goals. Also, by adding a quiz available to all users (something that became very popular in the last years in the video game market with games like Buzz selling over 6 million copies [31]) it is possible to have more entertainment and to promote social activity between the users, at the same time that they were being informed about environmental issues.

In order for this solution to be implemented and to study innovative forms of interaction that influence users to use it, it was necessary to have a smartphone able to detect users' actions. It is important not to focus on the technology that everyone has, but the technology that everyone will have. What today may just be a niche of the market, can soon become the mainstream technology. Gaea was developed for the iOS, which can be used by iPhone, iPad and iPod Touch devices (although at this time the iPod Touch does not support GPS nor compass, which are needed by the application). Therefore, the iPhone 4 was used to test and implement the prototype, which had all the features and technology needed by this solution. The public ambient display was connected to a computer, running the server's application, waiting for requests from the mobile devices, which acted as clients. The communication between the server and the clients can be done through Wi-Fi using the Bonjour protocol, or through 3G using AsyncSocket (a TCP/IP socket networking library). Communication between the clients and Facebook was done by 3G, while the calculation of each player's location was done by GPS/A-GPS available on the mobile devices. Both the server application and the client application were developed in Objective C. More about the prototype implementation in chapter 5.

Due to the topics covered in the presented solution, this system was entitled Gaea, who is the primal Greek goddess of the Earth [32].

Taking into consideration the described objectives and the persuasive technology concepts, it was possible to establish early fundamental elements of the system. Considering the functional triad of persuasive technology [2], Gaea acts mainly as a media, providing a motivating simulated environment where users can rehearse a behavior that ultimately enable them to change their attitudes and behaviors in the real world. So, by suggesting users to recycle virtual waste, they can rehearse behaviors, which enable them to change their attitudes and behaviors in a real world setting. Also, by giving them virtual rewards, either from Facebook or from the activity itself, it further influences people to do recycling on a daily basis.

But to make this possible, it was necessary to approach the different persuasive principles, in order to know what would work and what would not. Considering the persuasive technologies tools:

- *Suggestion*: intervening at the right time at the right place is a fundamental aspect of the mobile persuasion. In this activity, there was a key moment to persuade the user: when the user has dropped an object into a recycle bin. No other moment offers the same kind of possibilities than this one, because on the other activity's states (walking to pick up an object and walking to drop an object into a recycle bin) the user is focused on different information (more specifically in the map on the mobile device). So, this was the right moment to present information about environmental aspects to the users, asking them to read it. As a result, a section with the information about environmental aspects was created (both on the mobile device and the public ambient display), called "Gaeapedia".
- *Conditioning*: by giving positive reinforcement to shape complex behaviors, it is possible to transform occasional attitudes into habits [2]. Therefore, after marking the information as read in the Gaeapedia section, was presented a notification so that

the user knew that he had been rewarded with some points for reading the information. The user acknowledges this and the next time he drops another object into a recycle bin, he will go again to the Gaeapedia section to read (and to mark as read) the next information. This ultimately results in a constant routine for the user, who is motivated to repeat this task in the future.

- *Tunneling*: the system presented may be too complex for some users (since it uses two devices: a mobile device and a public ambient display) and therefore it is crucial to guide the users (while persuading them) through their tasks. Also, it helps the implementation of the system, because the interface keeps the user "controlled", without the possibility to make unexpected actions. Thus, users were presented with proper interfaces that helped them focusing on their tasks, without being distracted, while being persuaded along the way. The objective of the persuasion was for the user to read the information about the environmental aspects.
- *Self-Monitoring*: as previously mentioned in section 2.1.1, allowing people to monitor themselves is a great way to change their attitudes or behaviors in order to achieve a particular goal. So, it was decided to implement a "Statistics" section in the mobile device, which allowed each user to access data related to his actions. Also, it was possible to compare each user's statistics with others by accessing the ranking in the public ambient display.

After analyzing the previous concepts, it was clear that the mobile application should have four sections: Home (which allowed the users to register on the system, as well as to read the activity's instructions), Map (with the locations of the virtual objects), Gaeapedia (which provides information regarding environmental aspects) and Statistics (that records and presents the user performance).

Finally, the social cues taken into account when computers act as persuasive social actors [2], were:

- *Physical*: the use of visually attractive elements in a software product has a higher chance to have success and to persuade users than those products that do not use these kind of elements [2]. Thus, it was given special attention to visual elements (like images, colors or symbols) during the implementation of the interface.
- *Language*: the language used through the whole system was always designed to reinforce positive attitudes and behaviors, in order to achieve several tasks (like reading the instructions, use Facebook Connect to register on the application or to share the user's experience and performance on his Facebook Wall). This way users feel more open towards persuasion [2].

On the next sections, it will be introduced more design decisions that helped to shape the final version of the solution presented.

3.2 Design Methodology

In order to achieve our goals, an iterative design process was followed. Iterative design [33] is mainly based on a cyclic process of designing, prototyping, evaluating and refining a new product, where users are constantly involved. Figure 6 demonstrates this.

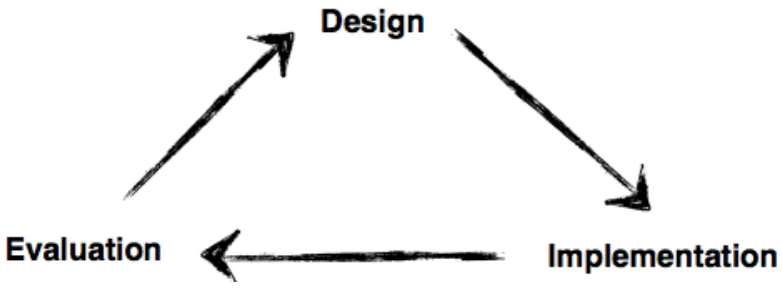

Fig. 6 - Iterative design

This process intends to improve the quality and functionality of the final interfaces (and product itself). The product evolves from low cost prototypes where multiple alternatives are explored, to more elaborated prototypes which have a high look and feel and where all features work as foreseen.

Gaea went through the following iterative design process:

- *User and task analysis*: which identifies the characteristics of the target user population. It is also determined and analyzed the tasks and their characteristics, that were initially allowed by the system.
- *Design, development and evaluation of a first prototype*: based on the tasks defined during task analysis. This prototype was used to conduct two user tests and an additional informal interview before advancing to the implementation of the computational prototype.
- *Refinement of design, decision-making regarding technology and interaction techniques*: according to the evaluation results of the first prototype, the development of the second prototype was planned.
- *Design, implementation and evaluation of the final system (computational prototype)*: at this stage, the system was implemented and went through the evaluation process, comprising the usability tests and the impact tests.
- *Analysis of results*: based on the data gathered from the computational prototype tests.

3.3 User and Task Analysis

The purpose of user and task analysis is to identify the users and what they need to do. Collecting and analyzing data about the users (characteristics and needs) and what they do, why, how and when they do it, permits a deeper knowledge regarding the system that should be implemented. This way it is possible to identify the individual tasks the system should perform, the goals of each task and how the overall goal of the system can be decomposed hierarchically into those tasks.

3.3.1 User Analysis

Regarding the target of this solution, it is primarily addressed to teenagers and young adults, and secondarily to children. It is important to note that teenagers and young adults represent a great part of social networks users [34], and the use of Facebook for children under 13 years old is discouraged [35]. Even though children do not have a Facebook account (or at least they should not have it) they can still freely use the application and participate in the activity. By doing so, it is expected that they learn the basics of recycling and the consequences of doing and not doing it. Obviously, older people can also participate, especially parents with their children (which helps promoting relationships between them). The application can also be used to support school activities, which promote competitiveness and knowledge between students, towards recycling.

Therefore users of this application can be segmented into two distinct types (of both genders):

1) *Primary Users*: users with age between 13 and 35 years old. It is expected that most of these users are students, which enables the realization of this activity at schools or by groups of friends. It is also expected that some of these users already have some kind of experience with iOS.
2) *Secondary Users*: users who are children (younger than 13 years old) who typically participate with their parents (older than 35 years old). Parents may or may not already have some experience with iOS, but it is expected that children do not have much experience with it.

It is important to notice that users and the audience of both of these types may or may not know each other, increasing or reducing the change of learning by watching users playing [22]. As stated in section 2.3.1, learning in *covert* interaction occurs primarily in groups of known people (since they exchange comments between them). It is important to present

instructions to what is happening, how to play, the goal of the activity and how the activity unfolds, in order that the audience learns individually.

3.3.2 Task Analysis

The implemented system allows, at least, the following high-level tasks:

Task 1: Registration	
Goals	Allow the users to be identified in the application so that the system (server) can recognize them among other users.
Pre-conditions	Pre-condition 1: The user is on a designated area for the activity to take place. Pre-condition 2: Access to the Internet (through 3G or Wi-Fi) if the user chooses to be identified by logging in with Facebook account.
Subtasks	This task can be done by choosing which mode the user wants to play (individual or team) and how he wants to be identified (by entering the first and last name or by logging in with Facebook account). a) If the user chooses to play individually, it is prompted to enter his personal data or Facebook account. b) If the user chooses to play in team, it is prompted to choose which team he wants to play in, and afterwards the user can select which identification method he wants to use (previous point).
Exceptions	It may not be possible to login with the user's Facebook account because the e-mail/password are incorrect or because there is not an Internet connection. It may also not be possible for a user to be registered if the activity is already taking place.

Task 2: Read the instructions

Goals Allow the user to read the instructions, in order to better understand the purpose and structure of the application.

Pre-conditions Users have done their identification.

Subtasks

Exceptions

Task 3: Start of the activity

Goals Allows the user to set as ready, in order for the system to know when to start the activity.

Pre-conditions Users have done their identification.

Subtasks

Exceptions Not all users selected that they were ready, and therefore the activity will not start. In this case a countdown will start in order to begin the activity.

Task 4: Pick up an object from the play area

Goals Allow the user to select an object to be picked up from the play area in order to bring into a recycle bin.

Pre-conditions Pre-condition 1: The activity is taking place.

Pre-condition 2: The user is near an object.

Pre-condition 3: The user is not carrying any other object.

Subtasks

Exceptions The user may not be able to pick up the object due to a concurrent action from other user (in other words, another user picked the same object a few milliseconds before).

Task 5: Drop an object into a recycle bin	
Goals	Allow the user to drop a previously picked up object into a recycle bin.
Pre-conditions	Pre-condition 1: The activity is taking place. Pre-condition 2: The user has picked up an object. Pre-condition 3: The user is near the public ambient display.
Subtasks	
Exceptions	

Task 6: Read information regarding environmental aspects	
Goals	Allow the user to read and mark as read the information regarding environmental aspects, after dropping an object into a recycle bin.
Pre-conditions	Pre-condition 1: The activity is taking place. Pre-condition 2: There is information unmarked as read.
Subtasks	Mark the information regarding environmental aspects as read.
Exceptions	

Task 7: Share user's experience and accomplishments through Facebook	
Goals	Allow the user to share his experience and accomplishments through Facebook at the end of the activity.
Pre-conditions	Pre-condition 1: The activity has ended. Pre-condition 2: The user has a Facebook account. Pre-condition 3: There is an active Internet connection (through 3G or Wi-Fi).

Task 7: Share user's experience and accomplishments through Facebook	
Subtasks	If the user has previously identified himself through his Facebook account, there are no subtasks. Otherwise, the user should enter his Facebook account and password.
Exceptions	It may not be possible to login with the user's Facebook account because the e-mail/password are incorrect or because there is not an Internet connection.

Some additional tasks, which were not foreseen in early stages of design, were implemented after the evaluation of the first prototype. These are described on section 4.4.

4. First Prototype

The use of initial prototyping is crucial during the development of a new product. It enables faster development and earlier feedback from users. Initial prototypes should be cheap and easy to modify, and most important, promote user-centered design. This allows users to better understand the design process that would otherwise not be possible when showing them abstract specification documents [49]. While it is expected that the early prototypes are low fidelity in terms of look and feel, they can include almost every features that are to be found on the computational prototype, which allows to make early design decisions that, on the long term, will save time and money.

4.1 Paper Prototype Description

Since the paper prototype presented to the users could not be included in this report (due to the low fidelity in look and feel that a hand-made sketch has), a computer mockup was created in order to give a better idea of the first prototype. Figures 7 to 10, show the initial design of the four sections of the mobile application (Home, Map, Gaeapedia and Statistics), made according to the user and task analysis and the goals of the system.

Fig. 7 - Initial Home section

Fig. 8 - Initial Map section

Fig. 9 - Initial Gaeapedia section

Fig. 10 - Initial Statistics section

The public ambient display is presented in figure 11.

Fig. 11 - Initial public ambient display screen

Therefore, our first prototype was a paper prototype easily built and changed, which helped to early detect problems in the user interface design. It focused on the global design and its evaluation provided different kinds of feedback (either from users testing it or from the audience watching it). Thus, the approach with this prototype was a "thrown-away" (or close-ended) type: the prototype was built and tested and the knowledge gained at this stage was used to develop the final prototype, but at the end, this prototype was thrown away.

4.2 Evaluation Methodology

The paper prototype was an interactive paper mock-up where users performed the instructions that were told them, by using their fingers to point to the several drawn-handed

buttons and were frequently encouraged to think aloud. During the evaluation, there were two stages of user testing: in the first one the interface was presented to the users shortly after it was finished (basically the interface did not reflect any kind of feedback from any user), and in the second one the interface presented to the users was changed to reflect the feedback gathered from the users after the first stage. During each stage, several notes (and even some ideas) were taken from users' feedback. Also, at the end of each test, some questions were asked to the users regarding their experience while using the prototype.

Participants

The first stage of user testing had a small number of users (four to be exact). These users belonged to the primary user group, with ages between 23-24 years, from both genders (two female and two male) and with medium/high experience with iOS. In the second stage of user testing, the number of users increased to twelve, each one with different kinds of knowledge and experience regarding iOS and computers, different age group (which ranged from 13-53 with an average of 27.8) and gender (five female and seven male). Furthermore, users that participated in the first stage of testing also participated in the second one. The graph next (fig. 12) details the participants in the second user test.

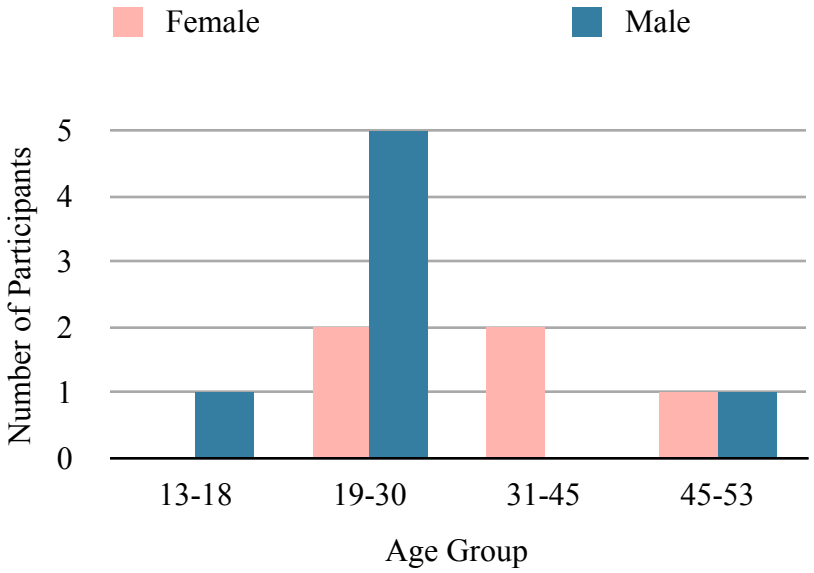

Fig. 12 - Graph detailing the participants in the second user test

Process

Before each test, users were asked to read the instructions presented to them on a computer. This was asked because the only information that a member of the audience has when he is waiting to play in a real setting, is the information on the public ambient display and the instructions (or purpose of the application) on a billboard or a flyer. Therefore, the following instructions were presented to each user:

> *"Imagine that you are on a garden or at a park or any other open space, where a physical activity can take place. Through the use of a mobile device it is possible to verify that the surrounding area has virtual waste scattered all over it, which must be recycled. In order to do it, it is necessary to walk to the object's locations and take them to the right recycle bin. To present general information about the activity, a public ambient display is used, allowing all people (participants and audience) to understand what is happening. On one hand users are competing while having fun, but on the other hand users are also being informed about the purpose of recycling and how it affects our planet."*

After users understood the purpose of the application, they were presented to the mobile device (which they should use to interact with the system) and the public ambient display. Three scenarios were presented to them, which described the task that they should accomplish during the test. Each scenario description was given to the users after they completed the previous one. The following scenario descriptions were presented to the users:

> **Scenario #1**: "*Using the mobile device, start playing as an individual player and insert your Facebook account information. Read the instructions and start playing. Head into the yogurt location, collect it from the play area and take it to the yellow recycle bin. Finally, read the information provided by the Gaeapedia."*

Scenario #2: "*Through the mobile device, choose to play in a team (more specifically in the same team as Pedro Centieiro) and insert your personal data. Read some instructions and start playing. Head into the yogurt location and collect it from the play area and take it to the blue recycle bin. Finally, check your performance."*

Scenario #3: "*The game is already taking place and you are already registered as a player. Read the information provided from the Gaeapedia. Check the map and head into the last object location, collect it from the play area and take it to the recycle bin that you think is suitable. Finally, choose to share your accomplishments on your Facebook Wall."*

As stated before, at the end of each test it was conducted a small and informal questionnaire about the experience that they had. The questions included: *"Did the interface felt simple and intuitive?"*, *"Where did you had more difficulties?"*, *"Did you felt that should be more interaction with the Map on the mobile device?"* and *"Did you liked the application?"*.

4.3 Discussion and Results

This section presents the prototype in detail, the feedback gathered from the users on both tests, and the prototype at different iteration stages (which was the result of the feedback gathered). It is important to stress that not all the interface screens are presented, only the most relevant ones. The final paper prototype version with all the interface screens is presented as a storyboard in the annex.

First Paper Prototype Test

Right after the initial paper prototype was developed, it was presented to several users. On the first stage of user testing, it was revealed several problems, some of them required major

overhauls of the interface. Thus, before presenting the prototype to more users, it was clear that these problems needed to be fixed. Table 2 summarizes the problems found during the first stage of user testing and the correspondents solutions:

Device	Section	Problem	Solution
Mobile Device	**Home**	Registration process is complicated and not intuitive.	Implement a step-by-step process.
			Apply tunneling persuasive tool.
		Users do not read all instructions.	Reduce the amount of text.
			Add a mechanism to navigate between instructions to simplify usage.
			Apply language social cue persuasive tool.
	Map	Text is not consistent which leads to confusion.	Make the text coherent and logical.
		Users do not know how many objects are left to recycle, while in other section of the interface.	Add the number of objects left to recycle next to the map icon.
		Users do not like to select the objects in order to know the possibilities of creating new objects with the objects selected.	Remove this feature from the mobile device and add it to the public ambient display.
	Gaeapedia	Users may mark the information as read, without really reading it.	Change “Mark as Read” button to “Mark as Heard”, in order to guarantee that the users paid attention to the information.
	Statistics	Section name does not feel accurate.	Rename “Statistics” into “Performance”.
		Score system is confusing and not clear enough.	Simplify the award points process.
Public Ambient Display	**Gaeapedia**	Text is not consistent which leads to confusion.	Make the text coherent and logical.

Device	Section	Problem	Solution
	State of the Game	Information regarding the number of objects already recycled does not have an add value.	Remove this feature.
			Add the possibilities of creating new objects with the objects presented in the map.

Table 2 - Problems found during the first paper prototype test

Right from the start, users felt confused about the registration process, because they were asked for personal data (first and last name) or instead they could login with their Facebook account. Users did not understand this (also because they were not familiar with the Facebook Connect button that was presented) and did not know what to do. After registering, users read the instructions in a hurry (not paying much attention to it), because there was too much information to read. So, clearly, the Home section needed to suffer an overhaul. This was made by adding a simple step-by-step process (like an installation wizard) where users were encouraged to use their Facebook account by showing them the benefits of using it. Regarding the instructions sub-section, a mechanism typical found on iOS applications (a segmented control which allows to switch between views), was introduced to the top bar on the right side, in order to simplify the navigation between instructions, so the users could read the instructions in a more quickly and simply way. Finally, the text was changed in order to induce users to read the instructions and to do the suggested actions. These changes can be seen on the figures 13-18:

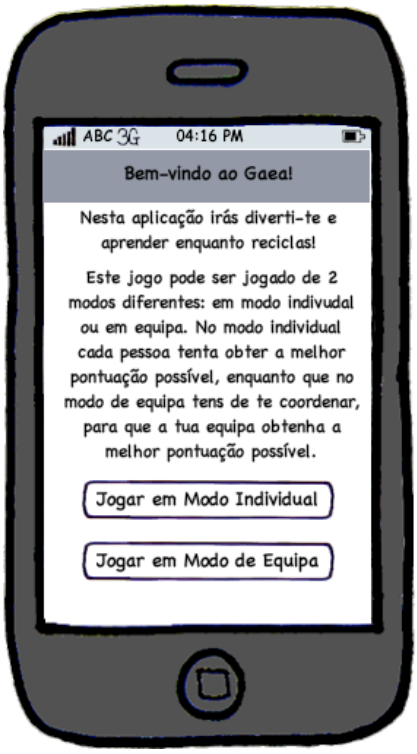

Fig. 13 - Welcome screen

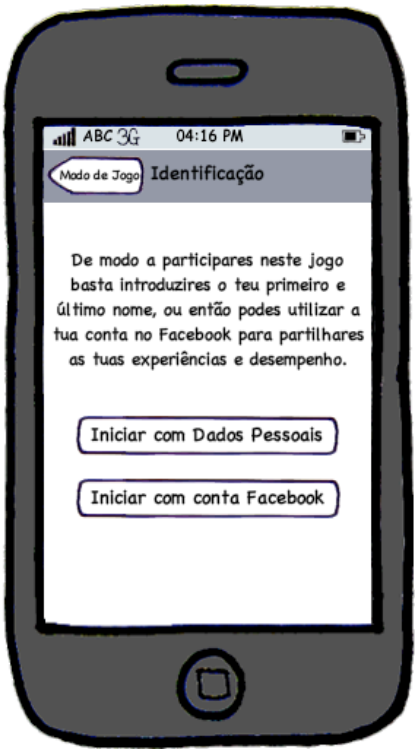

Fig. 14 - Identification screen

Fig. 15 - Facebook Connect

Fig. 16 - Home section

Fig. 17 - Instructions to Gaea

Fig. 18 - Instructions to Map

On the Map section it was found a common problem across the system: the information was not consistent and sometimes users felt confused. Also, in order to keep users posted of the map status while browsing other sections, it was added the number of objects left to recycle near the section button (on the second stage of user testing, users quickly understood what was the meaning of this number) as it can be seen on figure 19:

Fig. 19 - Number of objects left to recycle on the Map section button

Finally users complained about the need to select the objects on the map to know the possibilities of creating new objects with the selected objects. This feature was removed from the mobile interface and was added to the public ambient display.

On the Gaeapedia section, users marked the information as read without really reading it. This was not acceptable, because one of the main objectives of the prototype is to change users attitudes and behaviors towards a better environmental consciousness. The solution found was to change the button to “mark as heard”, which would force the users to listen to the marked information (this way it was assured that the user would not ignore the information presented, or at least, it was more difficult to do so) besides having the information displayed. Regarding the last section of the mobile application, Performance, the test showed that users were confused with the text presented to them about the “Objects Recycled” and “Objects Recycled Correctly”, and therefore this was removed.

On the public ambient display the major problem found was related to the information about the most recycled objects, which users did not show interest in. Therefore, this data information was removed and replaced by information concerning the possibilities of creating new objects with the objects recycled so far, as stated before. This feature displays the number of objects needed to create a specific item (i.e. five bottles of water are needed to a XL t-shirt [36]). This lets users know what can be done with the recycled objects and also helps them to decide what object they are going to recycle next. Figure 20 shows the public ambient display at the end of this first stage of testing.

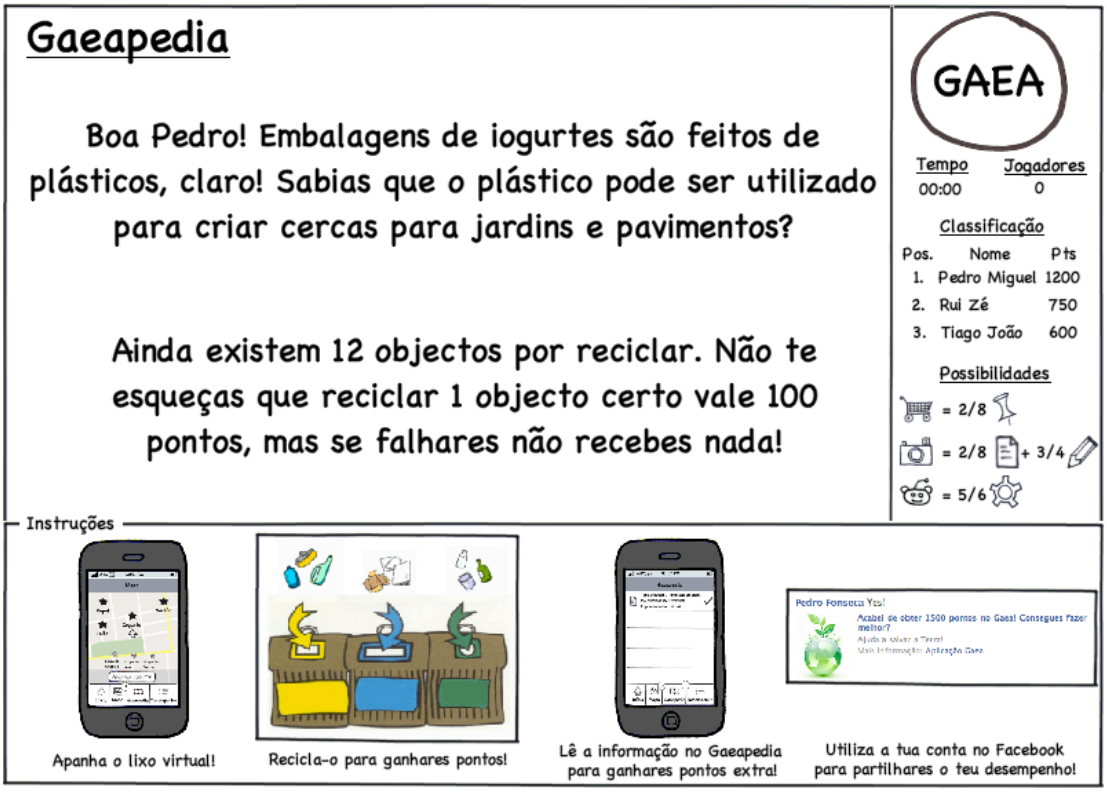

Fig. 20 - Public ambient display after an object has been recycled

Regarding the questions asked to the users, the feedback was diverse, because the interface had several flaws and while the users liked the application, they had some problems doing some tasks, which led to a troubled experience.

Second Paper Prototype Test

After the implementation of the previous described solutions, it was expected that the second stage of user testing would present less and small size problems. Table 3 shows that these expectations were met.

Device	Section	Problem	Solution
Mobile Device	**Home**	The name of the instructions' sub-sections is misguiding, causing users to use it, instead of the sections' themselves (fig. 12 and 13).	Rename "Gaea" into "What is **Gaea**?".
			Rename "Map" into "How does **Map** work?".
			Rename "Gaeapedia" into "What is **Gaeapedia**?".
			Rename "Performance" into "What can I access in **Performance**?".
	Map	When playing in team mode, users can forget in which team they are and therefore, do not know which object to pick up.	Add a note with the name of the user's team.
		The message to check the public ambient display is not entirely enlightening.	Change the message for something clearer.
	Gaeapedia	Users did not like to be forced to hear the information.	Remove "Mark as Heard" button.
			Add "Mark as Read" button back, but it becomes enable only a few seconds after the view loads.
Public Ambient Display	**Gaeapedia**	Users do not know that they need to check the Gaeapedia section on the mobile device.	Add a tip to inform the user to check his Gaeapedia section after recycling an object.

Table 3 - Problems found during the second paper prototype test

Although more users participated in the second stage of user testing, it did not translate into more problems. For instance, the Home section only showed problems regarding the name of the instructions' sub-sections (which had the same names of the application's sections') and some users would select them mistakenly. Therefore, these instructions sub-sections have been renamed into something that resembled instructions. Below (figs. 21 and 22) are the differences between the instruction sub-sections:

Fig. 21 - Home section after first test

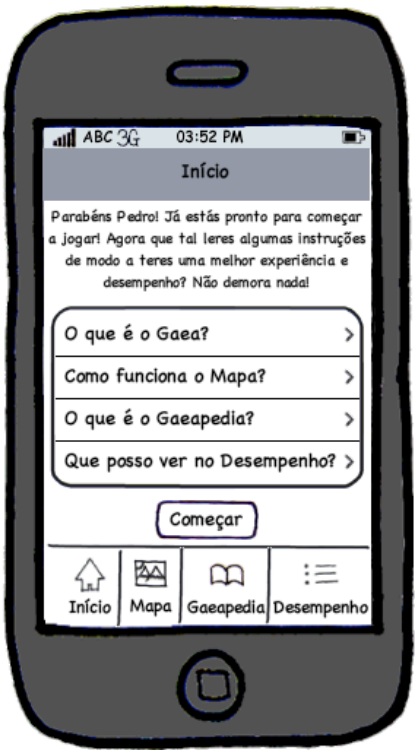

Fig. 22 - Home section after second test

On the Map section, it was common for some users to forget about which team they belong to and therefore a note with the name of the user's team was added. Also the message to look at the public ambient display (i.e. when dropping an object on a recycle bin, the user must look at the public ambient display, but some users did not understand it) was not entirely enlightening, and therefore it was changed into something more clear. A similar problem was found and corrected on the public ambient display, because users would sometimes forget to check the Gaeapedia section on the mobile device, after dropping an object into a recycle bin.

Finally, on the Gaeapedia section the "Mark as Heard" button was removed and the "Mark as Read" was added back. Users did not like to be constantly hearing the text that was written. While they understood that people should pay attention to the text, it was clearer that this was not the best solution. So, the "Mark as Read" button was added back with one

difference: initially the button is disabled, but after a few seconds after the view loads (this was the average time taken by a user to read the information displayed) it becomes enabled and the user may select it. So the user must wait the same amount of time it takes to read the text, before they can mark it as read (even if he did not read it).

Regarding the questions asked at the end of the test, the feedback was clearly positive and while some users took a little to understand the interface (specially the ones who have never used iOS), they all felt that the interface was intuitive and simple to use. For example, users completed the scenarios #2 and #3 more easily and quickly than scenario #1, showing that after the initial adaptation, the application is easy to interact with. Finally, all users liked the application and they showed interest to test it again when it was implemented.

4.4 Additional Features

After the evaluation of the paper prototypes there were still some doubts about some features of the public ambient display as well as on the mobile application. Therefore, six potential users with a relevant knowledge on computing science were interviewed in a informal manner, regarding their opinions about the system. Based on their suggestions additional improvements were made:

Device	Section	Suggestion
Mobile Device	**Home**	At the end of the activity it should be possible to present the ranking with the profile photos of the users who used Facebook Connect to register in the system.
	Map	Instead of selecting a button to pick up an object, it should be possible to select the object (which would get bigger when a user approaches) right on the map itself.

Device	Section	Suggestion
		Instead of selecting a button to drop an object into a recycle bin when near it, it should be possible to face to the public ambient display when near it, and rotate the mobile device to horizontal position (as if we want to take a picture) to reveal an augment reality view of the public ambient display containing the three recycle bins. Then, the user can select one of them by touching it.
Mobile Device and Public Ambient Display	**Gaeaquiz**	A new section was proposed, Gaeaquiz, which should ask questions about the information that users accessed in the Gaeapedia on the mobile device, in order to know if they really read and can recall it. This feature should be presented to the users only after all the objects have been dropped into the recycle bins, in order to keep the users focused on that task. Then, Gaeaquiz appears both on the public ambient display and the mobile devices. The public ambient display presents a question to all the users (and the audience), as well as the three possibilities to answer the question. Although, only the users can select the right answer on their mobile devices. Each right answer awards points, while wrong answers do not reward any. This process repeats until all the questions have been answered (each question corresponds to information given on Gaeapedia, when an object was dropped on a recycle bin).
Public Ambient Display	**All**	The public ambient display should have dynamic screens instead of a static one. This means that there should be several screens, each one with specific information, instead of only one screen will all the information. This also becomes very important to help creating a "honey-pot" effect since it is expected that people will be curious about what is coming next. A solution based on a rotating cube was found, where each screen corresponds to a cube face, which are rotating while the activity takes place: 1) *Home screen*: used while registration phase takes

Device	Section	Suggestion
		place and only appears once (when the activity starts); 2) *Map screen*: which shows the map, depicting players and objects' locations. It alternates together with the Instruction, State of the Game and Gaeapedia screens. 3) *Instruction screen*: with the instructions previously presented on the public ambient display (on first and second tests). 4) *State of the Game screen*: with the information about ranking, time, players and the possibilities of creating new objects with the objects presented on the map. 5) *Gaeapedia screen*: with the feedback about user's actions as previously mentioned. It appears only when someone drops an object into a recycle bin. 6) *Gaeaquiz screen*: presented only when all the objects have been dropped into the recycle bins. More about how specifically this feature works on the next chapter.

The new features on the Map section of the mobile device, made it necessary to update the task analysis regarding the task "Drop an object into a recycle bin". Moreover, it was necessary to add a new task regarding the Gaeaquiz section. These changes are presented below:

Task 5: Drop an object into a recycle bin	
Goals	Allow the user to drop a previously picked up object into a recycle bin.
Pre-conditions	Pre-condition 1: The activity is taking place. Pre-condition 2: The user has picked up an object. Pre-condition 3: The user is near the public ambient display. Pre-condition 4: The user is facing the public ambient display. Pre-condition 5: The user has rotated the device into a horizontal position.

Task 5: Drop an object into a recycle bin

Subtasks

Exceptions

Task 8: Answer the Gaeaquiz

Goals Allow the user to answer the questions about the environmental aspects, presented by the public ambient display.

Pre-conditions All objects have been dropped into the recycle bins or the time limit was reached.

Subtasks

Exceptions A user may not answer a question, which will result as a wrong answer.

Finally, figures 23 to 33 present the interfaces for these new features:

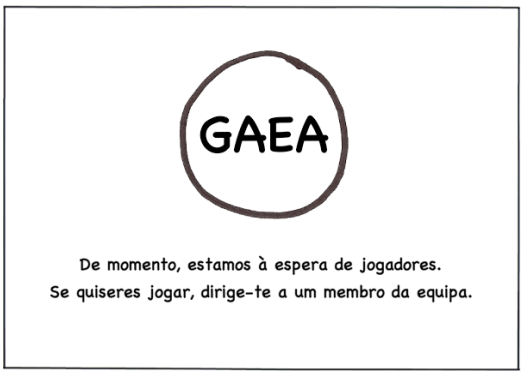

Fig. 23 - Home screen

Fig. 24 - Map screen

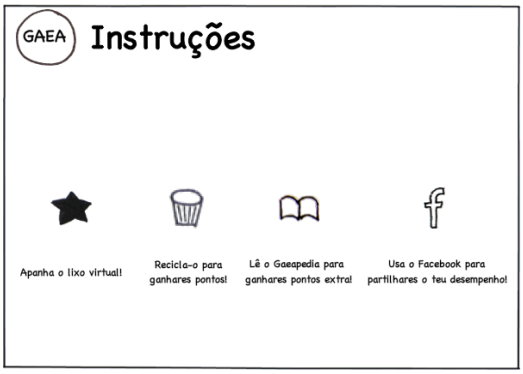

Fig. 25 - Instructions screen

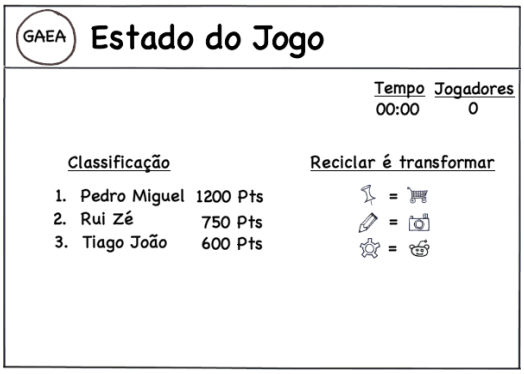

Fig. 26 - State of the Game screen

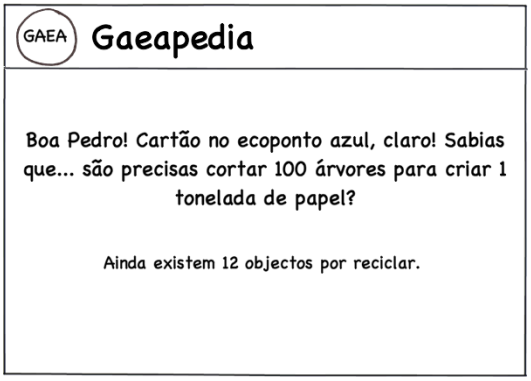

Fig. 27 - Gaeapedia screen

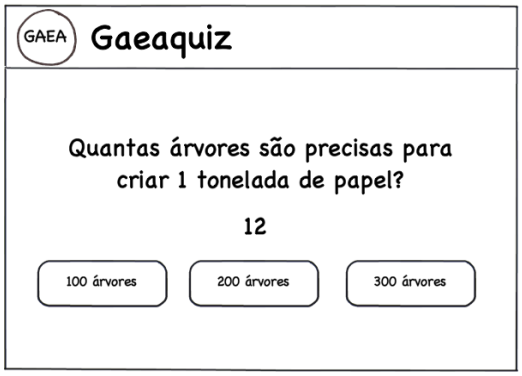

Fig. 28 - Gaeaquiz presenting a question

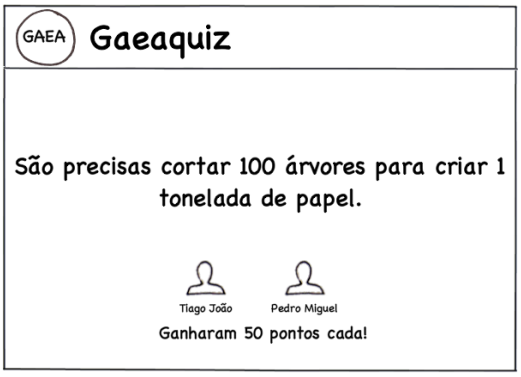

Fig. 29 - Gaeaquiz presenting an answer

Fig. 30 - Picking up an object

Fig. 31 - Dropping an object

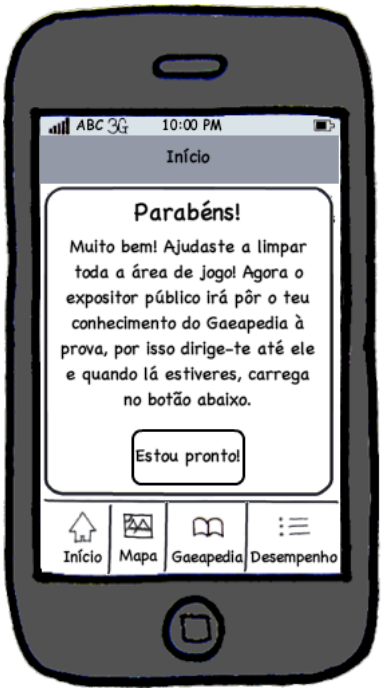

Fig. 32 - Alert before starting Gaeaquiz

Fig. 33 - Possibilities of answers in Gaeaquiz

A complete storyboard can be found in the annex.

5. Second Prototype

According to the results obtained during the evaluation of the paper prototype, a second prototype (computer prototype) was developed. While first prototypes are initial sketches of the system and are focused on the global design, second prototypes represent the final version of the system implemented, focusing on the users' experiences and interactions with it.

The second prototype was developed in Objective C. All the code was written on Xcode and all the interfaces were built on Interface Builder (although some interface components were generated through code in Xcode). The client application was developed to be compatible with iOS 4.2 (or higher) running on iPhone 4, iPhone 3GS and iPad with 3G (or better) while the server application is compatible with Mac OS X 10.6 or higher (meaning that it does not run on PowerPC architecture). Design elements like icons, backgrounds and images were developed using Adobe Photoshop CS4 and Adobe Illustrator.

5.1 Design

Since the purpose of Gaea is to persuade users to change their attitudes and behaviors towards recycling, the use of persuasive technology played a major role in the design of Gaea. Based on this technology, section 3.1 presented the early fundamental elements of the system, which allowed to establish the goals of Gaea, as well as the guidelines of how users should accomplish those goals. With the first prototype it was possible to adjust those guidelines, and even add new features that helped to define a better user experience. Thus, before starting to implement this prototype, the following design decisions were set:

- *Three Phases*: Gaea comprises three phases: registration, recycling and quiz (each of them with their own interfaces). Users must start by registering on the system, entering their personal data (first and last name) or entering their Facebook account data (e-mail and password). The recycling phase is the main and longer phase. During this phase, users can catch virtual objects from the play area and bring them to the recycle bins accessible when they are near the public ambient display. Whenever they do that, they receive information regarding the recycled object. This information was taken from several websites that displayed facts about recycling [36, 38-46]. The virtual objects were chosen accordingly to their frequency of use at people's houses (based on the recycling rules of the Sociedade Ponto Verde website [47]). Finally, during the quiz phase users answer several questions based on the information that was given to them after dropping the objects on the recycle bins. Having individual interfaces for each phase, allowed users to be focused on their current goal in each of these phases.
- *Scoring System*: there are three ways of earning points: recycling an object (100 points), marking the information provided by the Gaeapedia as read (50 points) and correctly answering a question during Gaeaquiz (also 50 points). The primary objective is to recycle the objects on the play area, therefore a high number of points is awarded to that action. The other two actions can be seen as extra points, but in order to persuade users to read and memorize the information in Gaeapedia, these actions needed to be worth the reward.
- *Two Play Modes*: Gaea is a multiplayer game that can be played individually or in team mode, where the score of a team is the sum of all the scores of the players in it. The goal is the same on both modes, but team mode has some specific characteristics. There are three teams of different colors (blue, yellow and green) which one charged to pick up the objects matching the recycle bin of its team color. However, there is a twist: if a team member collects an object that does not belong to its recycle bin, the points are going to be awarded to the team that the object

corresponds to. This is made so that team members work as a team, by deciding which objects they should collect.

- *Map*: it was decided not to use Google Maps (or any other web mapping service application) to show the objects and users' locations. This was made because the experience would not have the same immersive surrounds, when compared to a custom map designed specifically for this activity (like the ones from parks or golf courses). So, it was necessary to make calculations to convert the geographic coordinates gathered by the GPS of each of the users' mobile devices and objects into pixels, based on the map width and height. Also, when the compass is being used, the map must rotate accordingly to the direction the user is pointing to. These features are explained in detail later, on section 5.2.
- *Object's Locations*: the locations of the objects can be generated in two ways: in a grid (matrix) where each cell have an object in it, and by setting a different number of possible locations for objects. The first approach is based in an area (known as the play area) where it is only necessary to know two geographic coordinates: the northwest and the southeast. After entering them and the number of objects that we want to include in the activity, the grid and the positions of the objects are automatically generated (more about how it works on section 5.2). This approach is more appropriate when the play area is a wide space with no buildings nor obstacles. The second approach is not so automatic, demanding the insertion of all the possible locations where objects can be placed on the play area. Then, the system randomly chooses the different locations from all the possible options, where the objects are going to appear. Unlike the previous approach, this one is best suited when there are buildings and obstacles that do not allow having a wide spatial area where to spread the objects to be picked up. Therefore, by spreading objects around or between buildings, it is possible to have a different, yet, engaging activity.
- *Graphic Design*: as mentioned in section 3.1, special attention was given to visual elements of the interface during the implementation of Gaea. An example of that are all the images used in the prototype that have two different resolutions: 320x480

resolution (used in iPhone 3GS) and 640x960 resolution (used in iPhone 4). This means that when the mobile application is running on iPhone 3GS, it loads the images with 320x480 resolution, otherwise it loads the images with 640x960 resolution.

- *Facebook*: to try to achieve a massive number of people, an external application was created on Facebook (making it possible to share users' experience on their Facebook Walls from the mobile application), as well as a Facebook page for the DEAP project, which contained information about Gaea (and in the future about other prototypes). When users share their experiences on their Facebook Walls through the mobile application at the end of the activity, their friends could see what was Gaea and the DEAP project by simply clicking a link on the message generated by the mobile application. The messages that were shared, were created to be tailored to a specific person, instead of creating messages that sounded generic. This was made to create a persuasive experience in order to achieve mass interpersonal persuasion. For example, the user's score, sex and the city where the activity took place are taken into account to personalize the message to be shared on the user's Facebook Wall. If the user's name is Pedro, he is at Almada and he has got 500 points, the message shall be: "**Pedro** just got a **good** score in Gaea, which corresponded to **500** points! The area of **Almada** is cleaner thanks to Pedro! Can you do better?". However, if he is at Leiria and he got 2000 points, the message shall be: "**Pedro** just got a **magnificence** score in Gaea, which corresponded to **2000** points! The area of **Leiria** is cleaner thanks to Pedro! Can you do better?".

Gaea is based upon a client-server architecture (or model). This architecture fits in the two types of settings where the activity can take place: in an area where there is a wide wireless network (in order for the clients to connect to the server) and in an area with no wireless network. In the first case, all the traffic between the clients and the server is made through the local network (LAN), while in the second one the traffic is made through the Internet (WAN). This required the implementation of the network layer to support both types

of settings. Table 4 sums up the differences between the two network models supported by the prototype:

Characteristic	LAN	WAN
Setting	Best used where a wide wireless network is available with several access points scattered through the area (like a university or enterprise campus).	Best used where there is not a wireless network, in order for the clients to connect to the server (like a park or a garden).
Connection Type	Communication between server and clients is made through Wi-Fi.	Communication between server and clients is made through 3G.
Protocol and Libraries used	The Bonjour protocol was used (widely used on Mac OS X and also known as zero-configuration networking protocol), which enables automatic discovery of computers, devices, and services on IP local networks. Bonjour uses industry standard IP protocols to allow devices to automatically discover each other without the need to enter IP addresses or configure DNS servers [37]. The libraries used can be found on the Foundation framework of the Objective C.	Since the Bonjour protocol cannot be used on a WAN, the AsyncSocket library was used, which is a TCP/IP socket networking library. AsyncSocket offers asynchronous operation, and a native Cocoa class complete with delegate support [48].
Access Speed	Very fast, since it uses 802.11b/g/n Wi-Fi.	Fast, although it depends on the data plan connection registered for the device.

Characteristic	LAN	WAN
Monetary Cost	No cost. Communication is made through the local network.	There is a cost, because the communication is made through the Internet. However, since many iPhone/iPad users have data plans registered to their devices and the traffic is very low (around 0,5-1mb for an activity session), this was not seen as a problem.

Table 4 - Differences between the two network models supported by the prototype

Figures 34 and 35 show an overview of these two network models:

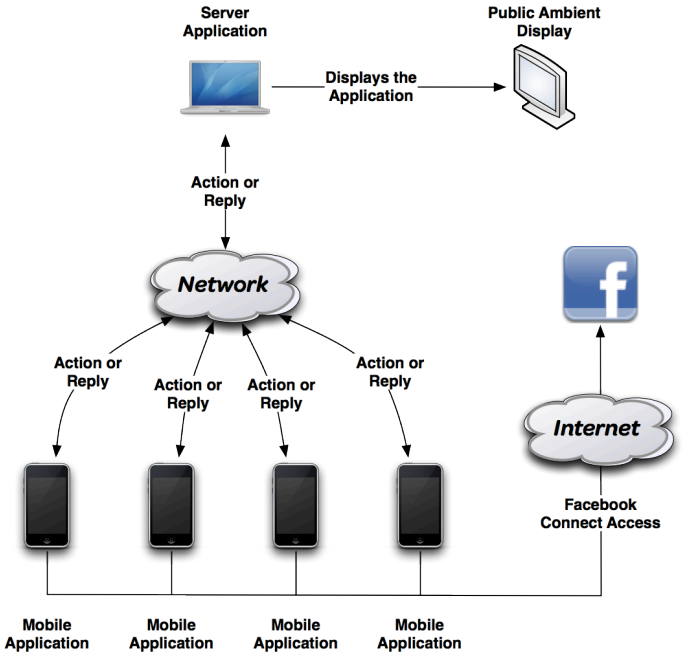

Fig. 34 - LAN overview model

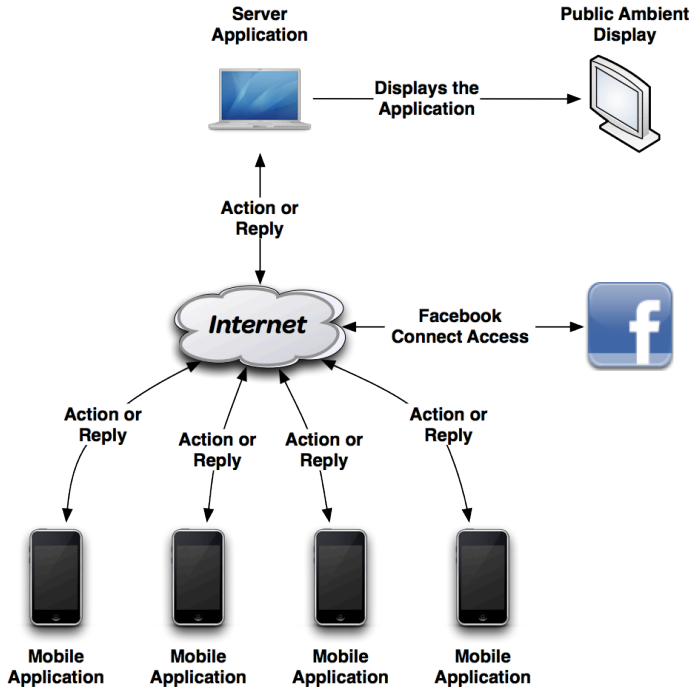

Fig. 35 - WAN overview model

Regarding the design of the server application, the public ambient display took an overhaul from its initial design, in order to have dynamic characteristics which would help to create a "honey-pot" effect. These characteristics consist on a rotating cube where each face corresponds to a specific feature of the application: Home, Map, Instructions, State of the Game, Gaeapedia and Gaeaquiz. The activity starts in the Home screen and as soon as all the user set themselves as ready (on the client application), the cube rotates to the Map screen. As mentioned in section 4.4, for the remaining of the activity, the public ambient display mostly alternates between three features: Map, Instructions and State of the Game. When someone drops an object in a recycle bin, the public ambient display shows the Gaeapedia screen, and then switches to the State of the Game screen. If it is the last object on the play area, it will then switch to the Gaeaquiz, and after all the questions have been presented, the public ambient display shows the final ranking and the activity ends. On figure 36 it is presented the screen flow depicting these features on the public ambient display (based upon the first prototype developed).

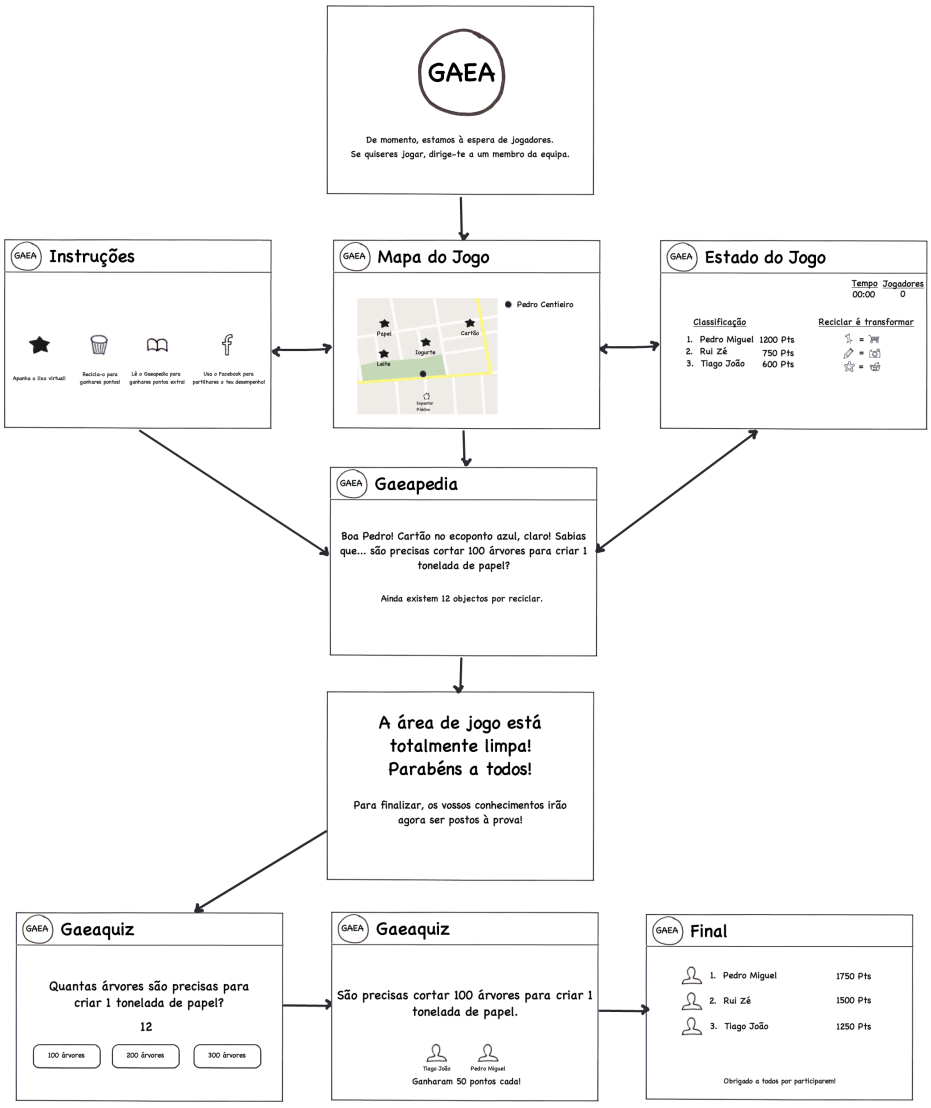

Fig. 36 - Screen flow of the public ambient display

There are some important design rules that were defined when setting the screen flow (and cube faces for that matter):

1) The Home screen stands on the top of the cube. It is the first face to appear and only rotates once (on *x* axis) to the Map screen.
2) The Map screen is the first to be displayed when the activity starts (right after Home screen) because it is very interesting not only for the users but also for the

audience, to see right as the activity starts, the users' locations being updated in real time. It is the most important of all features that are being alternated since it displays the objects' and users' locations in real time during the activity. In order to appear more frequently it needs to be located between State of the Game and Instructions screens (we must not forget that we are talking about a cube that is rotating and by rotating it means only one movement on the *x* or *y* axis).

3) Instructions and State of the Game could be either at right or left of the Map. It was chosen to have the Instructions on the left and the State of the Game on the right. They all rotate on *y* axis. To move from one to the other, the Map screen must be shown in between.
4) The Gaeapedia must be in a cube face adjacent to Map, Instructions and State of the Game screens because any of these screens can change to Gaeapedia. The only way to implement this is to make a movement on the *x* axis, making the Gaeapedia the face on the bottom of the cube.
5) The State of the Game screen besides appearing during the usual rotation (with Instructions and Map screens) also appears after the Gaeapedia screen (when someone dropped an object into a recycle bin). This allows the user to see where he stands in the ranking, as well as, the possibilities of creating new objects with the objects recycled so far (more on this below).
6) Finally, the Gaeaquiz is placed on the last cube face (behind the Map). As it is adjacent to State of the Game, it only needs a movement to appear (when all objects have been dropped on the recycle bins and there is nothing to see on the map). Since the cube only has six faces and the Gaeaquiz is the last face to be displayed, it was chosen a different animation to present the remaining screens of this feature (Gaeaquiz questions and answers, and final ranking).

These design rules help to have a consistent interface with a well defined information flow, where users and audience can easily structure and predict (if they are watching the

activity for a while) what is going to be shown. Ultimately, it leads users and audience to have a better experience by learning how the activity unfolds.

A more detailed description of the system's features is presented next:

- *Home*: to inform that the activity is about to start but it is still in the registration mode. This means that the players are either entering their personal data on the mobile application, reading the instructions about the activity or waiting for other players to set as ready, in order for the activity to start. The duration of this screen is undefined. However, some rules apply to start the activity: first, if all the players set as ready, the activity starts and the public ambient display shows the Map feature; second, if a player sets as ready and all the players have already registered, but did not set themselves as ready, a 60 second countdown begins to start the activity; and third, if a player sets himself as ready and there is one player who have not registered yet, a 90 second countdown begins to start the activity. All these rules are intended to prevent players from taking too long to register/read the instructions, which would keep other players waiting. The Home screen is presented next (fig. 37).

Fig. 37 - Home screen

- *Map*: the purpose of the Map is to give users and the audience an overview of what is happening. Users can use the Map as a strategic element to know where the other players are, in order to choose which objects they can pick up more quickly. As for the audience, the Map tries to produce a "honey-pot" effect, since the player movement can be seen on the public ambient display, which arouses curiosity, interest and makes people socialize, by exchanging opinions and comments about what is happening. If a player picks up an object from the play area, the object disappears not only from the Map on the public ambient display but also from the Map on each of the player's mobile applications (since the server broadcasts this new status to all players). In the prototype, there are 24 objects available equally divided in three arrays by their types (paper, plastic/metal and glass). During each session it is chosen a randomly equal number of objects of each type (the number of total objects must be multiple of three). This is made to assure a balance between all the objects that must be recycled (objects are not repeatable), as well as, to assure an equal number of objects for all the teams in the team mode. Due to the relevant information that it contains, the Map screen that is displayed for the longest period of time: 25 seconds. The Map screen is depicted in fig. 38.

Fig. 38 - Map screen

- *Instructions*: as mentioned in section 2.3.1, it is crucial to give instructions to the audience on how to interact on a *covert* interaction [22]. So, this feature is mainly aimed for the audience, because users are supposed to know the instructions already (they read them on the mobile application before the activity started). Therefore, by reading the instructions, the audience will know how the game unfolds and what the objectives are. If members from the audience want to play next, they will have a deeper knowledge before starting that they would not have if these instructions would not be shown. Also, since Facebook is very popular, the Facebook icon was added in order to tell people that their accomplishments and experiences can be shared through Facebook, which will also help to generate interest from the audience. This screen has a duration of 10 seconds. Figure 39 shows the Instructions screen:

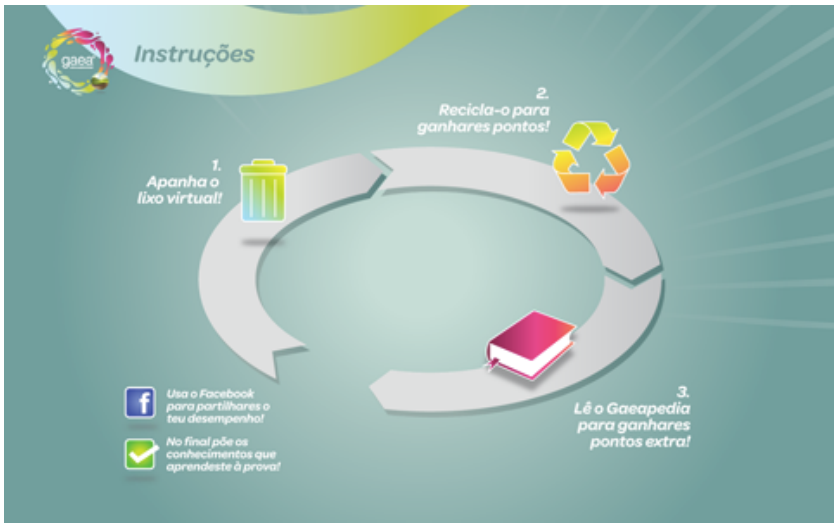

Fig. 39 - Instructions screen

- *State of the Game*: as the name implies, this screen is meant to show the current state of the game. The most popular information on it, is the classifacation, which allows users to know where they stand in the ranking. The information about the possibilities of creating new objects with the objects recycled so far is meant to inform users (and at the same time persuade people to recycle) about everyday

objects that we use at home, and that can have a new use after being recycled. This screen is displayed for 15 seconds. The State of the Game screen is presented in figure 40.

Fig. 40 - State of the Game screen

- *Gaeapedia*: this screen presents three important aspects. First, the feedback about the object that the user just dropped on the recycling bin (which allows the user to know if he dropped the object in the correct recycle bin). Second, the information regarding the type of object (paper, glass, plastic/metal) in order to provide the user and the audience with facts about environmental resources. And third, a small tip about the activity (like how much objects are left to recycle or how much points someone wins by recycling an object), so the user does not forget important information. The duration of this screen is 15 seconds, which was the average time for a person to read the information displayed and to understand it. The Gaeapedia screen is shown in figure 41.

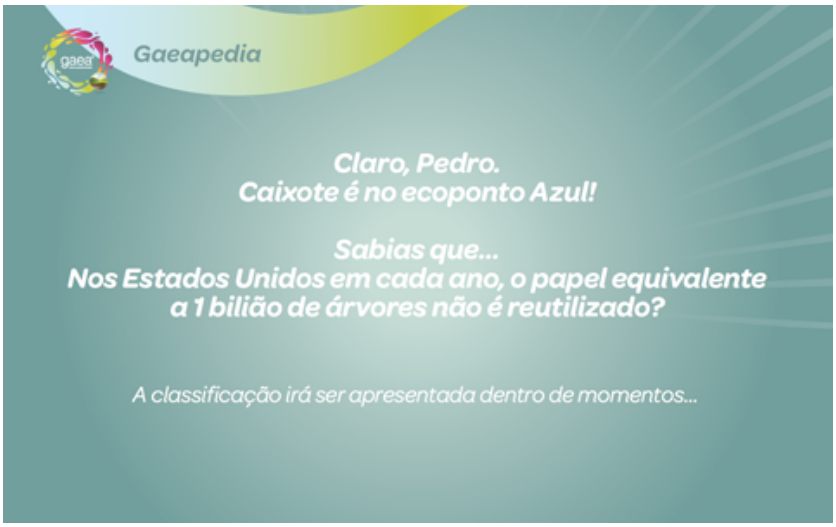

Fig. 41 - Gaeapedia screen

- *Gaeaquiz*: lastly, the Gaeaquiz is the definitive way to check if the users really read and paid attention to the information provided by the Gaeapedia throughout the activity. By telling users from early on, that a quiz about the information on Gaeapedia is going to take place after all the objects have been dropped on recycle bins, it makes them aware that they need to pay attention to that information. This is how we try to persuade users to be aware about the environmental topics related with recycling. Thus, this feature works as follows: after all players have set themselves as ready to start the quiz, a question appears (about an information that was presented during the activity) on the public ambient display, and users must select the right answer on their mobile device. The number of questions corresponds to the number of objects dropped on the recycle bins. There is a time limit (20 seconds) to answer a question and if a user gets the answer right, he is awarded with points, otherwise (time limit ended or he got it wrong) he does not get any points. After all users have answered or the time limit has been reached, another screen appears (during 10 seconds) showing the right answer, the users that chose the right answer, as well as their profile photos (if the player registered on Gaea through Facebook Connect, otherwise a default photo appears). This is an important feature not only to inform members in the audience, but also to help them, as well as the

users, to socialize and to exchange comments and opinions. Due to these characteristics, the duration of Gaeaquiz is undefined. The Gaeaquiz screens are presented on figures 42-45.

Fig. 42 - Gaeaquiz screen on public ambient display

Fig. 43 - Gaeaquiz screen presenting a question

Fig. 44 - Gaeaquiz screen presenting an answer on public ambient display

Fig. 45 - Ranking

The client application was the component that required more time and work. This was due to the technology involved in the Map section (GPS, compass and camera). The client application comprises six features:

- *Registration*: as mentioned in 3.3.2, this interface was readjusted to become a step-by-step process, which allowed users to enter their data in a easy and quick way. By

authenticating with Facebook Connect, the application gathers some user data (like the first and last name and the profile photo) and sends it to the server application, which will be used to identify the user throughout the activity. This authentication method was implemented with the Facebook API for iOS. The other method for registering (by entering the personal data) has some rules based on regular expressions that validate the names entered by users, to ensure that these have entered valid names. For example, the application checks if it contains numbers, special characters and if first names have more than two letters, among others. The purpose of asking users so few data is due to two factors: some people may not yet feel comfortable to type in a touch interface, and second because people feel more likely to fill short forms than long ones. When a user finishes the registration process, the data he entered is sent to the server. Registration screens are presented on figures 46-51.

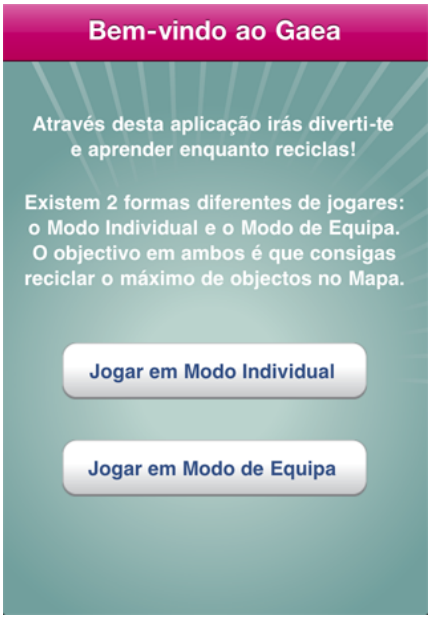

Fig. 46 - Welcome screen

Fig. 47 - Identification screen

Fig. 48 - Facebook Connect screen

Fig. 49 - Personal Data screen

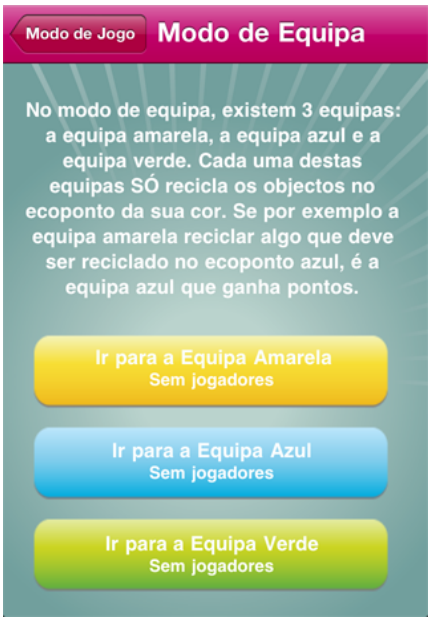

Fig. 50 - Team Selection screen

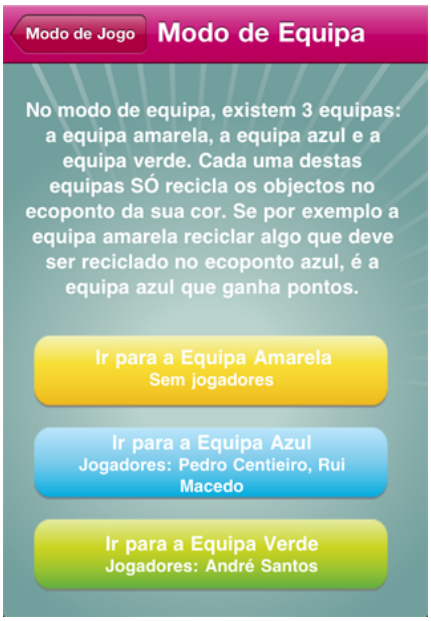

Fig. 51 - Team Selection screen with players

- *Home*: the Home feature can be seen as a waiting lounge where users can access the instructions and the "Start" button. A user is first greeted by a welcoming text, that

tries to persuade him to read the instructions. As referred in 3.3.2, there are four topics of instructions: “What is Gaea?”, “How does Map work?”, “What is Gaeapedia?”, “What can I access in Performance?”, which are meant to give information about the four sections of the mobile application. If the user tries to select any of those four sections, an alert appears stating that they cannot access them before the activity starts (this is made to keep the user focused on the Home screen). When the user wants, he can select the “Start button” and a loading view appears, preventing any other user interaction until the activity starts. The message sent by the server to each client to start the activity, includes the information required for the activity to take place (like the objects’ information and position, and the information related to each one of them in the Gaeapedia section). Figures 52-56 show the Home screens:

Fig. 52 - Home section

Fig. 53 - Instructions regarding Gaea

Fig. 54 - Instructions to Map screen

Fig. 55 - Instructions regarding Gaeapedia section

Fig. 56 - Instructions regarding Performance section

- *Map*: when the activity starts, the mobile application automatically selects the Map section. The purpose of this action is to guide users, so they immediately, know that

there are objects surrounding them and that they can start walking towards them. The user can then be guided in two ways: with or without compass. In both cases the user's location is updated on the map. When navigating without the compass the user is guided in the traditional way: the map is fixed, while the user's location is being updated. However, if the user selects the compass on the top right corner of the screen, the map (and the objects) is rotated when the user rotates the mobile device, so that the user knows which way he is facing. The user can deactivate this feature at any time, by simply selecting the compass again. This feature is meant for users to have a better perception of where they are and where are the objects. Since there may be some users that do not want to use the compass to be guided, it was decided to implement it as an optional feature. When the user is near an object, he just needs to select it from the Map to collect it. This action sends a message to the server to remove the object from the public ambient display's map, and also from the map displayed on the other mobile devices (through broadcast). When the user arrives near the public ambient display and wants to drop the object into a recycle bin, he just needs to rotate the mobile device, which will activate the camera. Based on the concepts of augmented reality, the user can point it to the public ambient display for the recycle bins to appear. The user then selects the recycle bin that he feels right and the public ambient display changes to the Gaeapedia screen, while the mobile device shows a loading view informing the user to check the public ambient display. After this, the Map is displayed once again. Figures 57 and 58 present some of these actions.

Fig. 57 - Map view (user is near an object)

Fig. 58 - Public ambient display augmented with the recycle bins

- *Gaeapedia*: in the mobile application, the Gaeapedia records all the information that the user was awarded, by dropping objects in the recycle bins. This information is presented in a list (order by the most recent for easy access). Each information item (cell) contains the object icon, an environmental information regarding the type of object (paper, glass or plastic/metal) and a mark button. This mark button allows users to mark the information as read and only appears three seconds after the user accessed Gaeapedia, which is the average time for the user to read the information. This is made to prevent users from selecting all the mark buttons without really reading the information associated to them. If the user has several cells to read, the timer is based on the last cell read (in other words, the user can only mark one at a time and in a specific order). When one information item is marked as read, an image of a medal appears, indicating the number of points awarded (50 Pts) below it. This acknowledge the user that by marking the information as read he is being awarded with points, motivating him to continue to do so. A message is then sent to

the server, so the public ambient display updates the user's score. The Gaeapedia screens are presented in figures 59 and 60.

Fig. 59 - Before marking as read

Fig. 60 - After marking as read

- *Performance*: although this feature does not involve any user interaction, its purpose cannot be despised. It is meant for users to monitor their actions and the score that they have been awarded so far. It also eliminates the cognitive effort that they would have if they would need to remember their performance. In the Performance section, the following information is presented: number of recycled objects and the points awarded for those actions, number of information items read on Gaeapedia and the points awarded for those actions, and the sum of all points (score). Figure 61 presents the Performance screen.

Fig. 61 - Performance section

- *Gaeaquiz*: this feature presents users with the possibilities answers to the questions proposed by the public ambient display, regarding the information presented by Gaeapedia throughout the activity. Each time a new question appears in the public ambient display, the server sends a message to all connected clients containing the three possibilities to answer the question (also shown on the public ambient display). Each user chooses the option he thinks is correct and after it, the interface presents a loading view that prevents user interaction until another question is presented by the public ambient display display. When all users have answered the question (or the countdown ends) the results are presented on the public ambient display. In the end, users are persuaded to share their experiences on their Facebook Walls (also implemented with the Facebook API) and set to "Like" DEAP project in the Facebook, allowing them to be notified with news about the DEAP project and Gaea events. This action was not supported by the Facebook API, and therefore it was necessary to implement it by accessing Facebook through a web page. The Gaeaquiz screens can be seen in figures 62-65.

Fig. 62 - Gaeaquiz section

Fig. 63 - Gaeaquiz screen presenting the possible answers on mobile device

Fig. 64 - End of the activity

Fig. 65 - Sharing data on the Facebook

5.2 Implementation

The implementation of Gaea can be divided in its two components: the public ambient display (server application) and the mobile device (the client application). Since it is impossible to describe the implementation of all the features and details of these components, is is only described the most important ones. These are grouped with the corresponding classes in tables 5 and 6. Each class has an header (ExampleClass.h) where the global variables are declared, while the implementation file (ExampleClass.m) holds the methods used by the application. There are also the User Interface Resources (XIB) files, which are used to help building the interface, but these are not detailed, since they simply hold the interface elements.

Server Application

Classes	Description
AsyncSocket, Message, Server; Service, Connection, LocalServer	Classes that handle all the network communication. The first three are used by the WAN version of the prototype, while the others are used by the LAN version. The AsyncSocket class [48] handles the connections, disconnections, writes and reads from each one of the clients' sockets. The Message class holds the content exchanged between the clients and server. This content is a dictionary where each key is associated with a specific data (either is a string, an array, or any other object type). The Server class is responsible for sending the messages to the clients, and delegating the received messages to be handled by the proper controller classes.

Classes	Description
	The Service class creates and publishes the Bonjour service for the clients to connect to, and the Connection class is the equivalent of the AsyncSocket class, but in a higher level, thanks to the libraries on the Foundation framework of Objective C. Finally, the LocalServer class has the same purpose of the Server class, but it is structured slightly differently due to the characteristics of the AsyncSocket and Bonjour libraries.
Waste, Player, Team, GameSession	Data classes created to hold the necessary variables.
AnimatingTabView	Auxiliary class [50] to control the cube rotation between screens. Each controller class is a tab view.
HomeController	Class that handles the start of the activity, based on the received clients' messages who set themselves as ready. When the activity starts, it switches to the next tab view (in this case, MapController) and this class becomes the new delegate to handle the receiving messages. It also activates a timer, in order to know when the next tab view has reached its intended duration. These actions are also implemented on the other controller classes.
MapController	Class that assigns the objects to their locations (during the activity's setup), and naturally, shows them and updates the location of the users on the map (during the activity). Regarding the manual method of choosing the objects locations, this is achieved by choosing each object from the objects array (which was populated accordingly to the rules mentioned before), and posteriorly placing it on one of the 24 possible locations, that were manually collected. The grid (automatic) method divides by a equal number of rows/columns, the difference between the play area northwest latitude/longitude and the play area southeast latitude/longitude, respectively, resulting in individual cells (the possible objects' locations). Then it randomly assigns each object to one (different) cell.

Classes	Description
	The other particular aspect of this class is the conversion from latitude and longitude to pixels. It is necessary to take into account two aspects. First, longitude corresponds to *x* in raster graphics and latitude corresponds to *y*. Second, a screenshot from the Google Maps was taken from the area that was meant to be drawn (thus, creating the custom map), as well as, it was collected the northwest and southeast coordinates of it. With this in mind, the conversion is achieved by cross-multiplication (rule of three), using the width's and height's image. All the objects' and users' locations are based on these conversions to be properly displayed on the map.
PerformanceController	Class that updates the users' ranking, the activity elapsed time far and shows the number of players and the seven possibilities of creating new objects with the objects recycled so far (which were gathered from Sociedade Ponto Verde [51]). Each one appears when the respective object is dropped into a recycle bin.
InstructionsController	This class only displays the instructions' image.
GaeapediaController	This class iterates the objects collection to check if an object was dropped in the corresponding recycle bin. It also shows the feedback of that action and the environmental information associated with the dropped object, as well as a random tip about the activity.
GaeaquizController, GaeaquizQuestionsController, GaeaquizAnswersController	The GaeaquizController class handles the start of the quiz, based on the received clients messages who set themselves as ready. As the name implies, the GaeaquizQuestionsController manages the questions presented, while the GaeaquizAnswersController shows the answers and displays the photos of the users who correctly answered the questions.
FinalController	Presents the activity final ranking.

Table 5 - Server applications' classes

Mobile Application

Classes	Description
AsyncSocket, Message, Client; Connection, ServiceBrowser, RemoteClient	These classes are similar to the classes used by the server application, but comprises the proper methods of a client. The names of the classes are also different: the Client class corresponds to the Server class, the RemoteClient corresponds to the LocalServer and the ServiceBrowser corresponds to the Service.
Waste, Player, Information	Data classes created to hold the necessary variables. Information class is an auxiliary class used in the GaeapediaController.
GaeaAppDelegate	Class that holds the data shared among the controller classes.
WelcomeController, IdentificationController, PersonalDataController, TeamController	The WelcomeController class is used to connect to the Server, through the Client class, and displays the initial screen. The IdentificationController uses the Facebook Connect API to request the Facebook user data. The PersonalDataController checks if the first and last names are valid through the use of a regular expression that should match each one of them. Lastly, the interesting aspect in the TeamController class is the possibility to see which players are in which teams, in order to have an idea of all teams. This is made through a request submitted to the server application when the TeamController view appears.
HomeController, InstructionsController	In the HomeController class, each one of the rows that allow to access the Instructions are called cells. To customize each one of these cells, it was necessary to create a specific class, HomeControllerCell, which managed each of the cells. In this case they simply act as data classes. The InstructionsController shows the instructions and implements the navigation method to switch between previous and next instruction.
MapController, RecycleBinController	The MapController apart from handling the conversion of geographic coordinates into pixels already explained in the server application, it also manages the compass operation.

Classes	Description
	To rotate the map accordingly to the direction that the user is facing, it is necessary to apply an affine transformation matrix based on the value received from the compass. The objects also suffer this transform but the applied value must be the symmetric value converted, so that the objects always stand right-side up to the user, regardless the rotation applied. There are other affine transformations that are used, like scaling an object when the user is near it or scaling an object to its normal state when the user moves away from it. The RecycleBinController class controls the augmented recycle bins. It uses the camera to display what the user is seeing through it, and the compass to check if the user is facing the public ambient display (if the heading is within a specific range). If he is, the recycle bins appear over the camera view, on the mobile device screen, allowing the user to select one of them.
GaeapediaController	The GaeapediaController class is a list of custom cells, each one with an associated GaeapediaControllerCell class. Each time a cell is set as read, a notification is sent to the server to update the user's score. It is also necessary to internally reload the list (this is not seen by the user) so that the countdown timer to display the next mark button begins.
PerformanceController	This class does the necessary calculations to show the correct data and score corresponding to the user's actions. This class also has a custom cell class, PerformanceControllerCell, that only holds data.
GaeaquizController, GaeaquizAnswersController, GaeaquizFacebookController	The GaeaquizController allows users to set themselves as ready. The GaeaquizAnswersController displays the buttons corresponding to the possible answers to a question, which were extracted from the message sent from the server. Since the Facebook API does not support the "Like" action, it was necessary to implement it in the GaeaquizFacebookController.

Classes	Description
	This method requires the user to login with his Facebook account through a web page, before selecting the “Like” button. However, this is made through the application and does not require the user to leave it.

Table 6 - Mobile applications’ classes

5.3 Usability Testing

Usability tests are of great importance to evaluate a product by letting the users perform specific actions or scenarios. The aim is to give direct input on how real users use the system, by observing them, and at the same time, discover errors and areas of improvement, that could not be detected during development or during controlled environment tests. The results of these tests should be treated as a baseline for all subsequent tests, in order to use them as a comparison model, and to ascertain the evolution of the system.

Methodology

Throughout the development of Gaea, some short usability tests took place to evaluate specific actions and features. However, due to particular characteristics of this prototype (like the geographically referenced objects and the multiplayer factor), it was not possible to fully test it without deploying it on a live setting, with several users and an audience. Thus, some user tests were conducted to assess how people would use the system, and how they would be affected by it.

These tests took place at FCT-UNL campus, where we had all the structure and equipment needed to execute them. The display was set up during an afternoon from 3 pm until 6 pm, in a prominent place (entrance of the department of computer science) in a way that people did not miss it. The projection screen had 4 meters wide and 3 meters tall (although the projection could not filled the entire screen), and the text was legible from

approximately 5-8 meters during daylight, and 12-15 meters during evening. The projector connected to the computer running the server application was positioned approximately 6 meters away from the projection screen. A team member stood next to the computer to install the mobile application on the several mobile devices used during the test session, to give instructions to the participants, and also to provide assistance to any problems that users might face. All four team members observed the way that the tests unfolded, and how users and audience reacted to what was happening. Figures 66 and 67 illustrate the setup assembled during daylight and evening.

Fig. 66 - System setup during daylight

Fig. 67 - System setup during evening

The first users started using the system around 3:30 pm, and the audience started to gather near the activity spot. People who had an iPhone started first, and then they lent them to people who were interested in using Gaea, but did not have an iPhone. The tests took around 10 minutes each, and were made in groups of three or four users (based on the number of devices available) and all the tests (except one) were played in the individual mode, where each user played by himself. There was one session that was played in team mode, but since there were not six iPhones available (minimum to have two users per team), we divided six people per three iPhones (two people for each device) to evaluate if members of the team interacted and socialized during the recycling and quiz phase. We noticed that this objective was fulfilled, not only on the team mode but on the individual mode as well, where players and audience interacted and socialized between them. This was supported by the increasing number of people in the area around the public ambient display, which created the already mentioned and expected "honey-pot" effect. This resulted in the physical space around the system becoming "marked", drawing in a crowd, and generating a little "buzz". During this stage, members of the audience asked questions and exchanged opinions and comments between them and with players, and rarely we needed to give instructions (apart from the initial debrief). In fact, instead of us asking the audience to participate, it was the members of the audience who asked us to participate, showing that after the audience assimilated how the activity unfolded, they were interested in interacting with the system. Figures 68 and 69 show the "honey-pot" effect created with a medium number of users.

Fig. 68 - "Honey-pot" effect before the start of a session

Fig. 69 - "Honey-pot" effect during the registration phase

As more people interacted with Gaea, more other people came along around the display, and the rate of participation increased over time as the evening went on, until there were not any users and audience left. The graph presented in figure 70 shows the timeline of the rate of participation, including the number of users and audience.

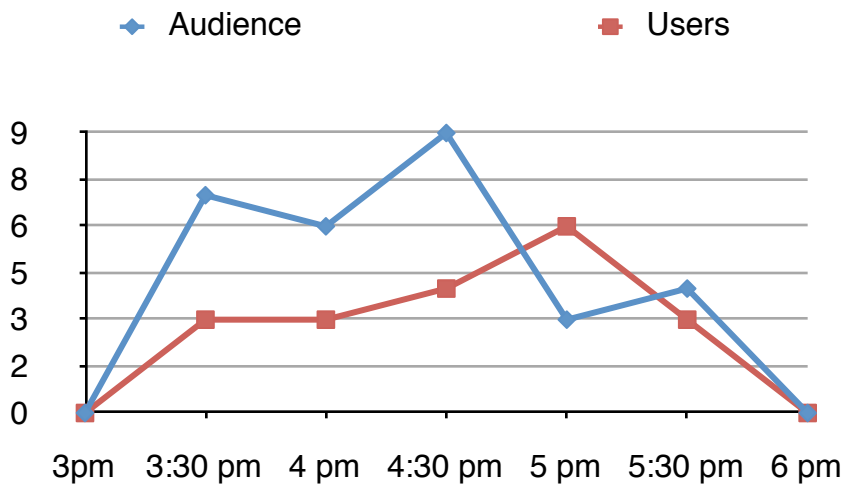

Fig. 70 - Graph detailing the rate of participation of users and audience

Finally, at the end of each session, each user were asked to answer a questionnaire (which can be found in the annex) to evaluate Gaea usability.

According to Nielsen and Landauer, the trade-off between the number of users and the number of usability problems found, come from testing with no more than five users [52]. This is because as we add more users to test the system, we are not detecting many new problems, others than the already discovered by the first users. As demonstrated in [52], we need at least fifteen users to able to discover all the usability problems. Although we did not have anticipated it (because it is hard to predict how many people will show up), this test session had fifteen participants and a small number of members of audience (around 25-30 people, not simultaneously), some of them also became users of the system. These numbers were not higher due to the exam season at FCT-UNL. There were not many people passing by, but most people who passed by the activity's spot was interested and wanted to participate. Users had ages within 23-44 years old (average of 32.2), from both genders (twelve male and three female). There were five users with PhD degrees, five with MSc degrees and five with BSc degrees. All of them were familiarized with new technologies, they all used computer, cellphone and the Internet on a daily basis. Most of them (eleven) rarely use a game console, two used it on a weekly basis, one on a daily basis and one did not use it. This data was extracted from the above referred questionnaire. The graph next (fig. 71) shows the participants' age and gender.

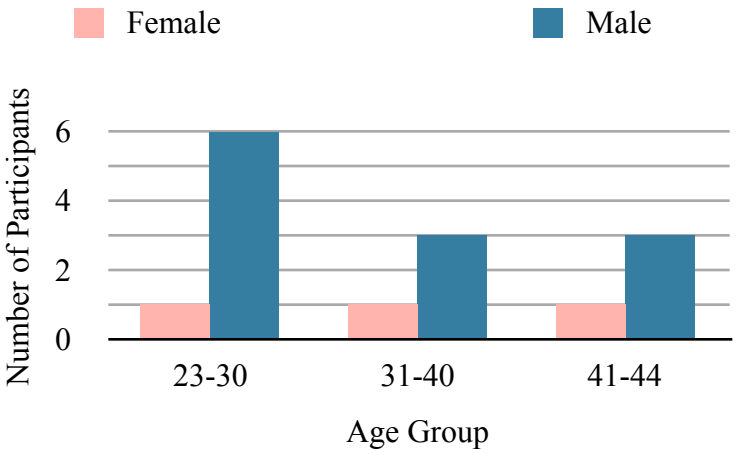

Fig. 71 - Graph detailing the participants in the usability test

Discussion and Results

The purpose of the questionnaire was not only to evaluate the prototype usability, but also people opinion towards recycling, before experiencing Gaea, and after experiencing it. This questionnaire was based on an article by Lund [53], which details a tool (called the USE Questionnaire) that helps to know if an interface is well designed, the problems that should take priority or the acceptable speed for completing a specific task. USE stands for Usefulness, Satisfaction, and Ease of use, and are the three dimensions that most strongly emerged in the early development of the USE Questionnaire. The idea is to ask users to rate their agreement with the statements, like "the system helps me be more effective" if we are evaluating the system's usefulness, "the system is simple to use" if we are evaluating the system ease of use, and "I am satisfied with the system" if we are evaluating the user's satisfaction, which is drove by the other two dimensions. These agreement rates range from strongly disagree to strongly agree, and they are constructed as seven-point Likert rating scales (on Gaea's questionnaire it was used a five-point Likert rating scale).

The first four statements of the questionnaire focus on general aspects of the interface related to the previous described three dimension concepts. Figure 72 shows these statements and their average rate of agreement.

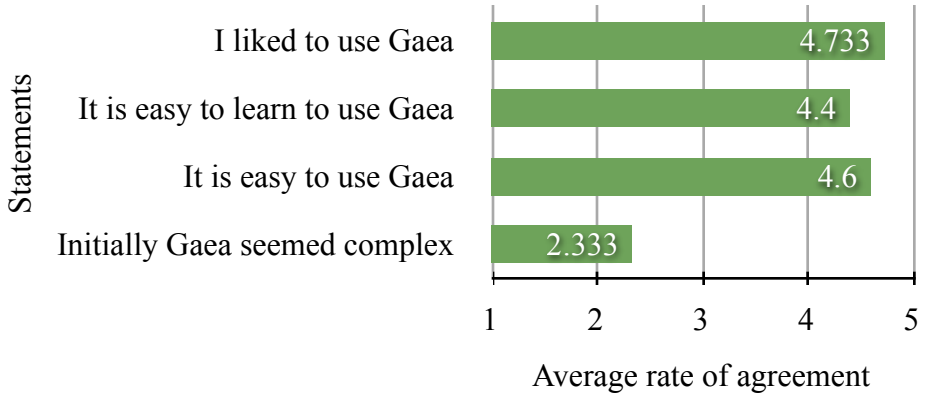

Fig. 72 - Evaluation of several general aspects of the system

In these first statements, the user feedback was very positive, demonstrating that users liked to use Gaea, that it was easy to use and to learn. The general feedback was that Gaea did not seem complex. It was expected that users felt that Gaea was complex before experiencing it (since it uses two devices: mobile device and the public ambient display) but this did not happen. This may be due to the users' age group and the familiarization that they had with new technologies. It is necessary to perform more tests with different users groups to evaluate if there are any differences.

Next, additional aspects of usability and ease of use were addressed. The graph presented (fig. 73) shows these results.

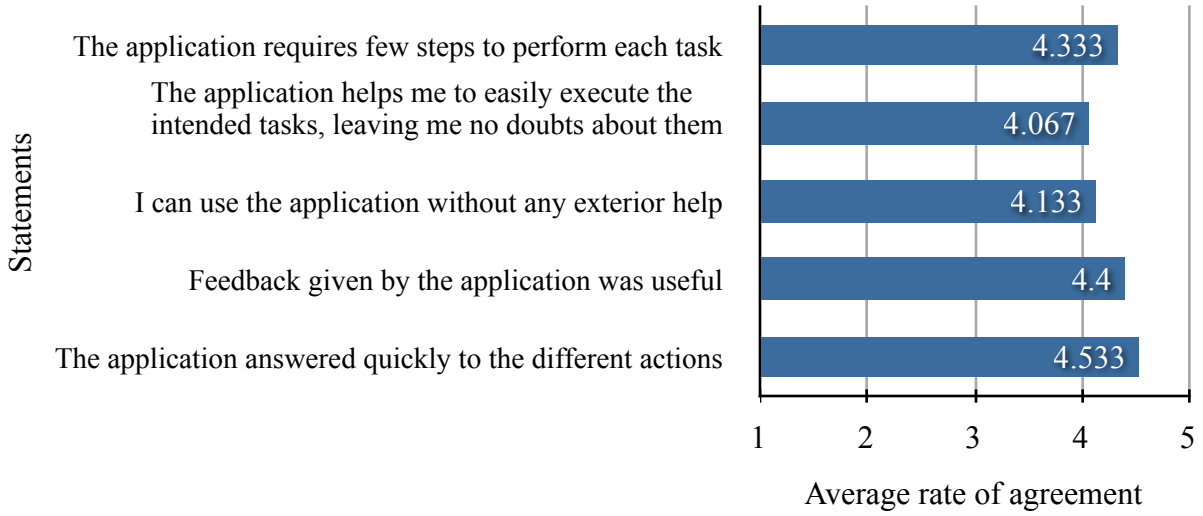

Fig. 73 - Average rate of agreement about usability and ease of use

In this case, the user feedback was also quite positive (all the scores were above 4.0). The first two statements were intended to evaluate the tunneling, suggestion and conditioning persuasive concepts, and the results show that the objectives were quite achieved. The next two statements reflect that the instructions given by the application were informative and useful (another important aspect that was supposed to be studied). Finally, it was evaluated the response speed to the different user's actions, which also received a very good score.

On the following graph (fig. 74) it is presented how easy it was for the participants to use Gaea specific features.

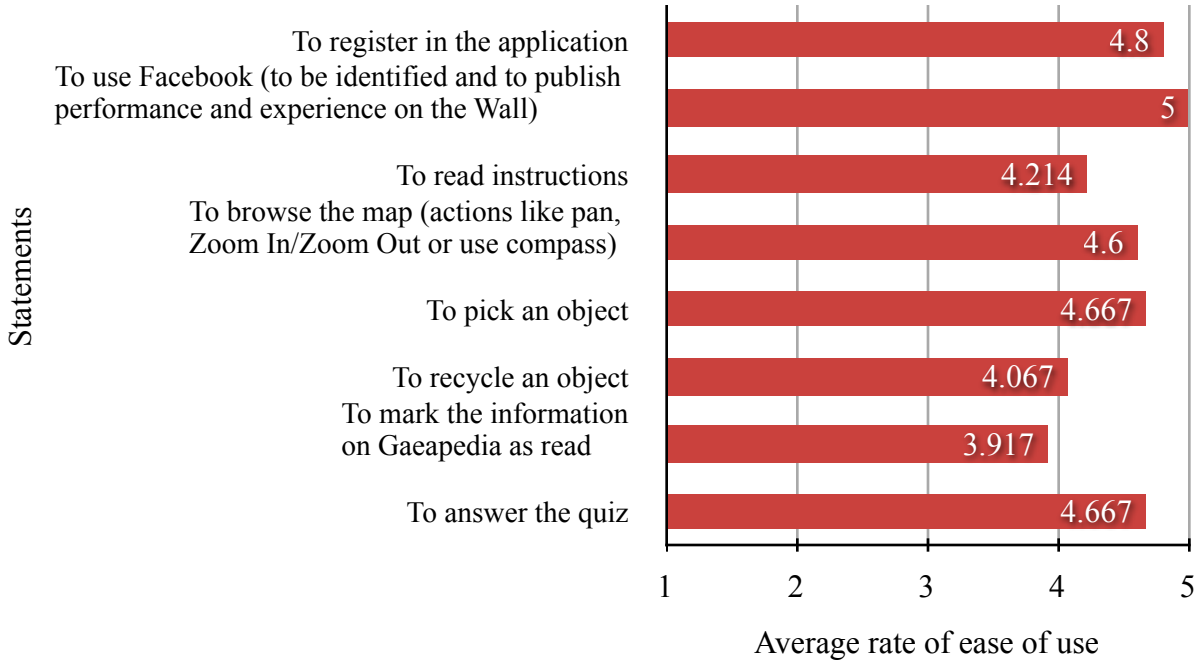

Fig. 74 - Average rate of ease of use about specific features

As the graph shows, the user feedback was very positive. However, it is necessary to take into account the least, yet, quite positive scores: marking the information on Gaeapedia as read and recycling an object. The first score can be explained by the fact that it was not clear to users that there was a new notification available on the Gaeapedia section, while the second score was due to the text informing the user to rotate the iPhone to an horizontal position (which generated some confusion). Both of these issues were quickly fixed: after

recycling an object for the first time, a pop-up appears prompting the user to check the Gaeapedia section, and the text to rotate the iPhone to a horizontal position was changed to clarify the user that he must position the iPhone like if he would like to take a picture. The Facebook feature's average rate is based on the only user who used it (although two more users used it on previous informal tests). More about this on section 5.4.

To evaluate the users' opinions towards recycling, the questionnaire also included some questions on how people felt about the topics promoted by Gaea, and if the experience with this prototype was meaningful in that way, and motivated them to change their attitudes and behaviors towards recycling. Figures 75-80 present the correspondenting results.

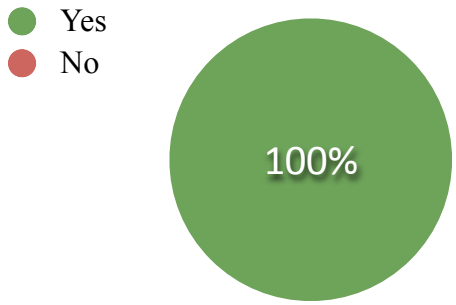

Fig. 75 - Question: "Topics addressed by Gaea are important?"

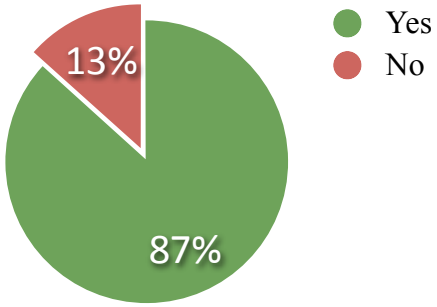

Fig. 76 - Question: "Did you learned with the information presented by Gaea?"

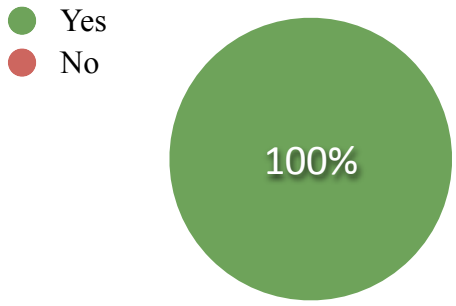

Fig. 77 - Question: "Does Gaea increases the awareness for the need to recycle?"

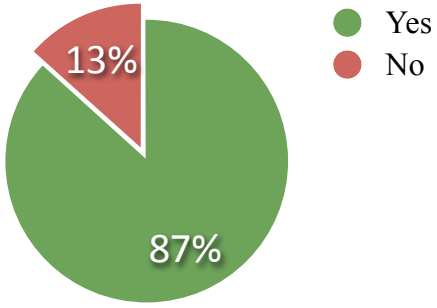

Fig. 78 - Question: "Before using Gaea did you recycle?"

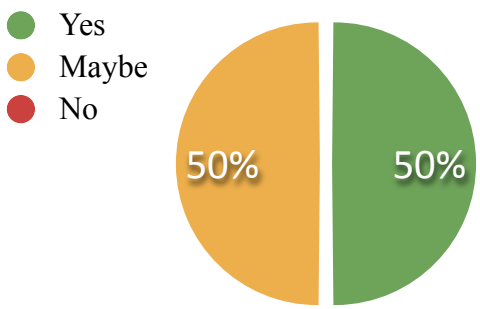

Fig. 79 - Question: "Are you now motivated to begin recycling?"

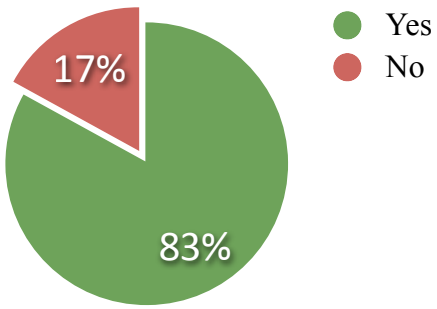

Fig. 80 - Question: "Are you more motivated to continue recycling?"

Based on these results, it is possible to conclude that Gaea managed to convey the intended message. Everyone expressed that the topics addressed by Gaea were important, and they all think that Gaea increases the awareness for the need to recycle. Almost all users learned with the information displayed by Gaea, and most users that recycled stated they felt more motivated to continue recycling after using Gaea (thirteen users answered this question). One of the users that did not recycle before experiencing Gaea, said that he will now start to recycle, and the other said that maybe he will start recycling.

The last part of the questionnaire, emotional involvement, was based on the Microsoft "Product Reaction Cards" [54, 55]. The purpose of using this method was to collect feedback on desirability and to measure the users' emotional involvement during the test. Thus, the users were asked to choose the words that best describe their experience, from a selected set of words. Figure 81 presents the graph with the obtained results.

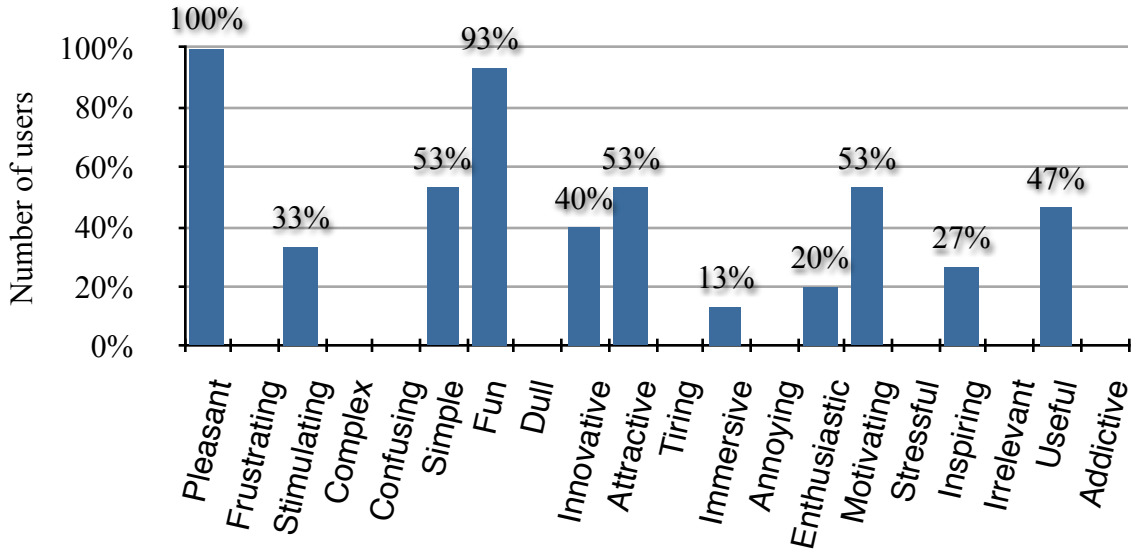

Fig. 81 - Emotional involvement about Gaea

The majority of users felt that Gaea was pleasant (100%) and fun (93%), which is very positive, because Gaea was designed exactly to encourage the audience to participate in it. More than half the users felt that Gaea was simple (53%), attractive (53%) and motivating (53%), other keys aspects of Gaea design. Almost half of the users said that Gaea was useful (47%) and innovative (40%).

Finally, users were prompted to enter suggestions and comments regarding future developments of features. For example, one user suggested that the application should allow users to pick up several objects at the same time. Steve Feiner was very enthusiastic about Gaea when he saw a demo during his visit to our lab in January 2011 and he also made this suggestion. Although we have already considered to implement it, it was decided not to, due to the associated problems that it implies (it can be implemented in the future, but is necessary to take a deeper approach to analyze its trade-off). The major problem is that the information provided by Gaeapedia would be quickly forgotten, since users would be getting a lot of information (one for each object) after recycling all the objects that they have picked up. Another use suggested that the mobile application should also show the location of all users. This is something that would have an impact in the number of messages being broadcasted by the server, and therefore, its consequences (mainly related to the network traffic) need to be studied. Moreover, having that information available only in the public

ambient display seems to be more challenging. Lastly, a user expressed his satisfaction with the application: “I liked the experience and the subject is very interesting. The application interface is very well done”.

5.4 Impact Testing

To study the impact of Gaea in users’ environmental attitudes, one week after the usability evaluation, we asked the participants to answer another questionnaire. It was intended to evaluate the behaviors and attitudes of the users, some time after experiencing Gaea, to acknowledge if users were still stimulated to make recycling a part of their everyday life, and if they were still aware of the environmental issues presented by Gaea.

Methodology

One week after the usability tests, users (the same users that participated in the usability evaluation) were handed a new questionnaire to fill (found in the annex). Ten users were given the questionnaire personally, while for the other five users, the questionnaire was sent by e-mail (this was because we could not met them personally).

Discussion and Results

Initially, the questionnaire was designed to only evaluate the users’ environmental behaviors and attitudes, but after noticing the low usage of the Facebook Connect feature on the usability tests, it was decided to ask the users why they did not use it. Therefore, the first graphs presented in figures 82 and 83 are related to the frequency of use of Facebook, and the reasons why some of the users did not use Facebook Connect on Gaea.

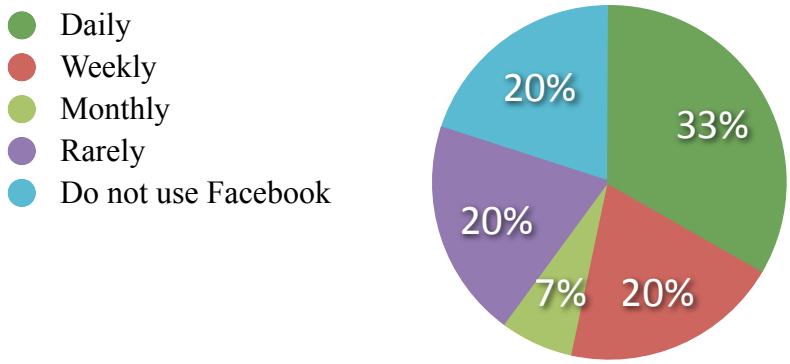

Fig. 82 - Question: "How often do you use Facebook?"

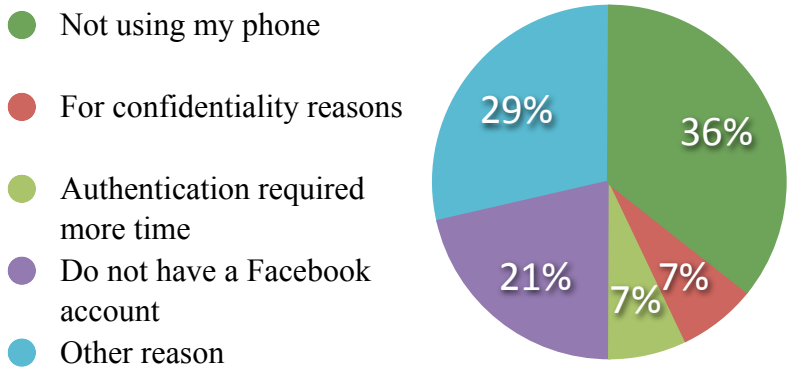

Fig. 83 - Question: "Why did not you use Facebook on Gaea?"

As it is shown in figure 81, a third of the users uses Facebook on a daily basis, while 20% uses it weekly, 7% uses it on a monthly basis and another 20% rarely uses it. It is important to note that 20% of the users do not use Facebook.

Figure 82 shows two of three major reasons why people not used the Facebook feature on Gaea: some users were not using their own phone during their experience with Gaea (we can not forget that some of the iPhones were lent to conduct the tests) and some did not have a Facebook account (therefore making it impossible to access Facebook feature). Two users also said that they do not use Facebook very often, and therefore they did not show interest in using it on Gaea. One user expressed that he did not use it only because he could not remember his password. Finally, another reason was the lack of information, regarding how

the application would handle the user's data, which discouraged the participant to use this feature.

The last part of this questionnaire is related to the users' environmental behaviors and attitudes. First, users were asked to rate their agreement with a statement about their awareness for the necessity to recycle, and second, users had to rate if their motivation to recycle since using Gaea after using Gaea, had decreased (lowest score) or increased (highest score). Figures 84 and 85 present the graphs with the obtained results.

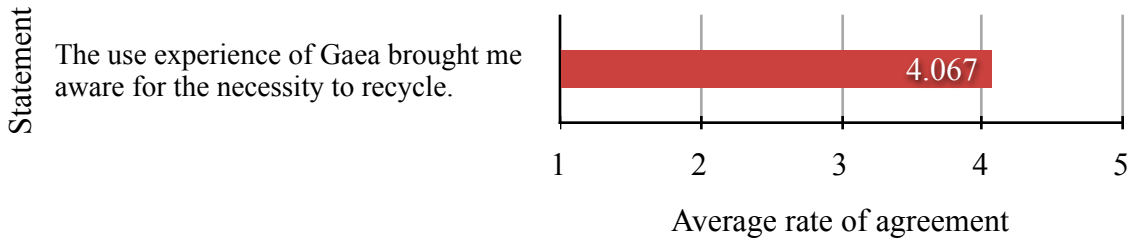

Fig. 84 - Average rate of agreement about the awareness for the necessity to recycle

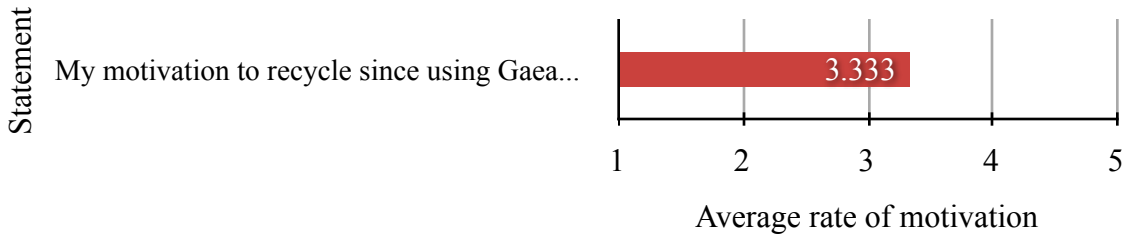

Fig. 85 - Average rate of motivation to recycle

Results show that the experience of using Gaea increases users' awareness about the need to recycle. The users' motivation to recycle after using Gaea also increased slightly. Although, a user noted that his levels of motivation could not be higher (he chose a rate of 3), because he already recycled everything. It is necessary to perform further tests (mainly with users who do not recycle) to verify the accuracy of these results.

One aspect that has great importance but has not been referred so far, is the analysis of the persuasion through Facebook, and its impact in the popularity of Gaea, as well as on the DEAP project. Even if the majority of the users did not use the Facebook Connect on Gaea, some of them accessed the DEAP project page on Facebook sometime later. By expressing

that they liked it (through the “Like” button), resulted in a few of their friends also visiting the DEAP project page. The results show that 46 users expressed that they liked the DEAP project, 105 unique users visited the page, which generated 4,629 post views in just one week. Although it was not possible to know so far, if all the users became more motivated to change their environmental behaviors and attitudes, this clearly shows that the use of social networks (in particularly Facebook) helped to advertise the project, the Gaea application and consequently the environmental awareness. By having this initial user base on Facebook, it is also possible to promote future projects and events that may be of interest to many people and may help to engage people in pro-environmental behaviors.

6. Conclusions and Future Work

This dissertation describes the use of persuasion technology through mobile phones and public ambient displays. It was developed a prototype, Gaea, that introduces innovative forms of interaction between mobile devices and public ambient displays, by detecting users' locations and actions on a specific geographical area. It applies the concepts of persuasion technology with the intent of affecting human attitudes and behaviors towards a better environmental consciousness.

Gaea is a persuasive location-based multiplayer mobile game, that prompts people to recycle virtual objects on a specific geographic area in a fun and appealing way. During user tests, almost everyone felt enthusiastic and had a good experience with Gaea, which gives us confidence for the future of this prototype. Regarding the analysis of the user tests, these revealed the following:

- *Good feedback from applying persuasive technology concepts*, making it a simple experience, with clear tasks, enabling users to be focused and motivated to achieve them.
- *Users had a pleasant and fun experience*, which eases the adoption of recycling habits, and also makes learning through Gaeapedia, an interesting and stimulating experience. Furthermore, more than half of the users found that Gaea was simple, attractive and motivating.
- *Interaction between mobile devices and public ambient displays*, foments social interaction between users and between members of the audience, and allows the dissemination of the information to a large number of people.
- *All users were aware for the need to recycle*, which is fundamental to appeal the citizens' conscience regarding the possible consequences of not recycling.

- *Users still had pro-environmental behaviors and attitudes some time after using Gaea*, demonstrating that the goals regarding the encouragement of this type of behaviors and attitudes have been accomplished.

Moreover, the use of social networks (like Facebook) allied to the mass interpersonal persuasion concepts, allowed to increase DEAP project's popularity, that could not be achieved without using them. Thus, results showed that the use of social networks can help to advertise the environmental awareness, in a simple and effective way.

We are also already preparing a paper to be submitted to INTERACT 2011, focusing on the interaction between mobile devices and public ambient displays, described in this dissertation.

6.1 Future Work

There are several opportunities for future work concerning the system described in this dissertation:

Implement fine tuning

It was clear that although the feedback from the usability tests was very positive, it is still necessary to implement some fine tuning, according to what has been observed during the usability tests. Furthermore, the installation procedure of the mobile application on the users' mobile devices must be made easier. These are important aspects that should be polished, before performing further tests with a greater number of users and audience.

Perform further tests with different user groups and settings

During this dissertation, it was not possible to perform further user tests, as we would have desired. Two of these tests were: to setup Gaea during a full day at classes season at FCT-

UNL, allowing to have a higher exposure with a greater number of users and audience, and to setup Gaea at Parque da Paz in Almada (in association with the Almada City Council), on the 22nd April, the Earth Day, in order to have different user groups and where parents can participate with their children. We have been invited to present Gaea (and plan to do further user tests) during ExpoFCT, an exposition of science, technology and innovation in FCT-UNL on 29th April, which had 8000 participants on the last year's edition. These tests are of great importance to promote pro-environmental behaviors and attitudes, and to keep studying the impact of this kind of interaction on different users.

Integrate additional social networking aspects

One concept that was planned, but was not implemented, was the Facebook social web game mentioned in section 3.1. At the DEAP project it is still our intention to develop a game to integrate with Gaea, in order to provide rewards, like items, virtual money and achievements that users could not get without participating in Gaea. This would result in a greater interest in participating in Gaea, allowing it to promote the environmental issues on a larger scale.

Develop a version available for download

We are planning to developed a different version of Gaea, in order to make it available for download at the Apple's App Store. This version will use Google Maps to show virtual objects near the user's location (anywhere in the world), and new objects will be presented to the user on a daily basis. It will not require the existence of a public ambient display, but it is mandatory to have a server application (available on the Internet) to track the users' performance.

Analyze the users' suggestions trade-offs

While all users' suggestions were valid, it is necessary to analyze their consequences (positives and negatives) before implementing them, as it was demonstrated in section 5.3. If all users' suggestions were implemented, it would lead to unforeseen consequences that could damage the intended user experience. For example, we hope to introduce the ability to collect several objects at the same time, but we must find a way of implementing it without the associated problems mentioned in section 5.3.

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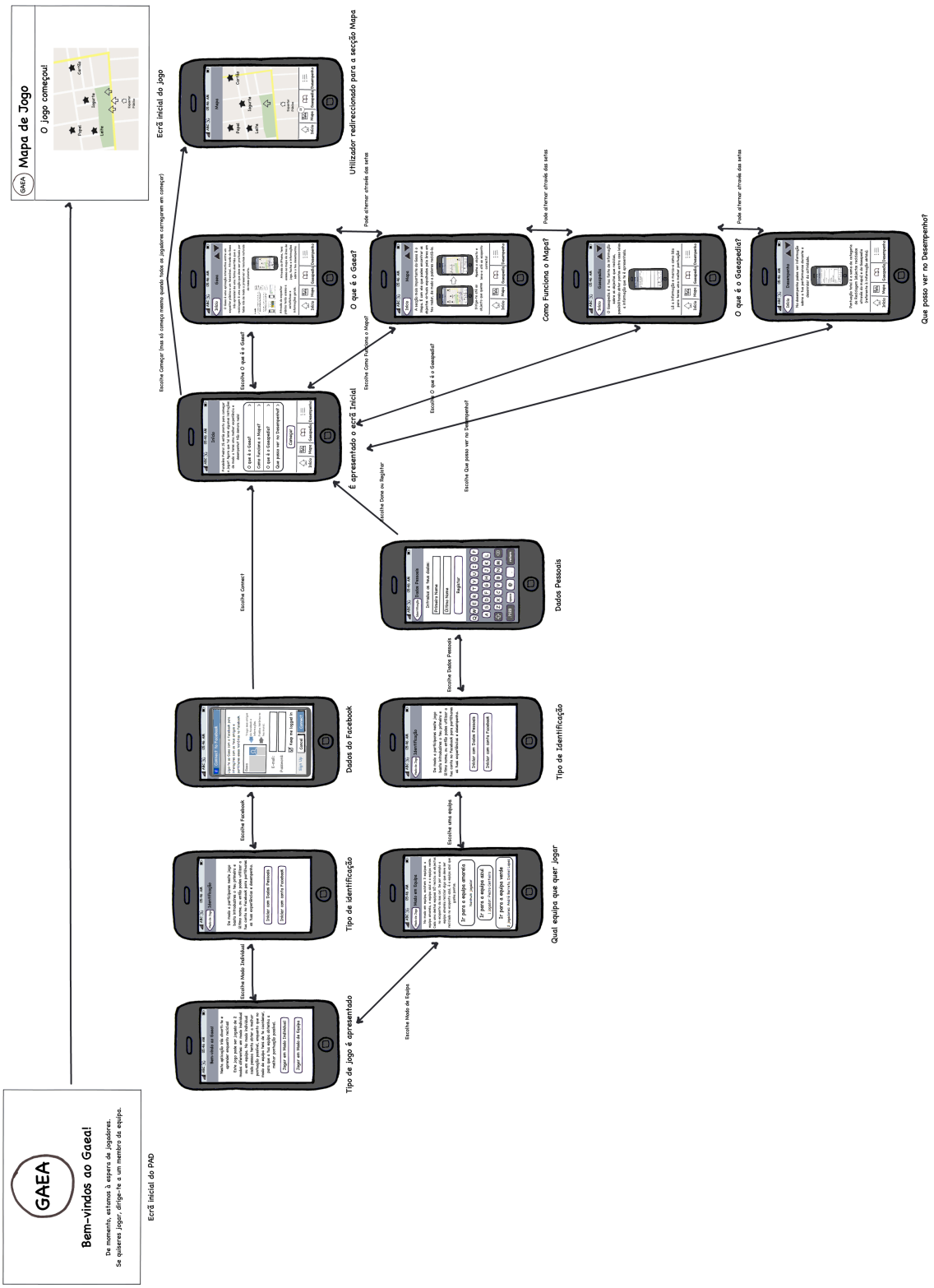
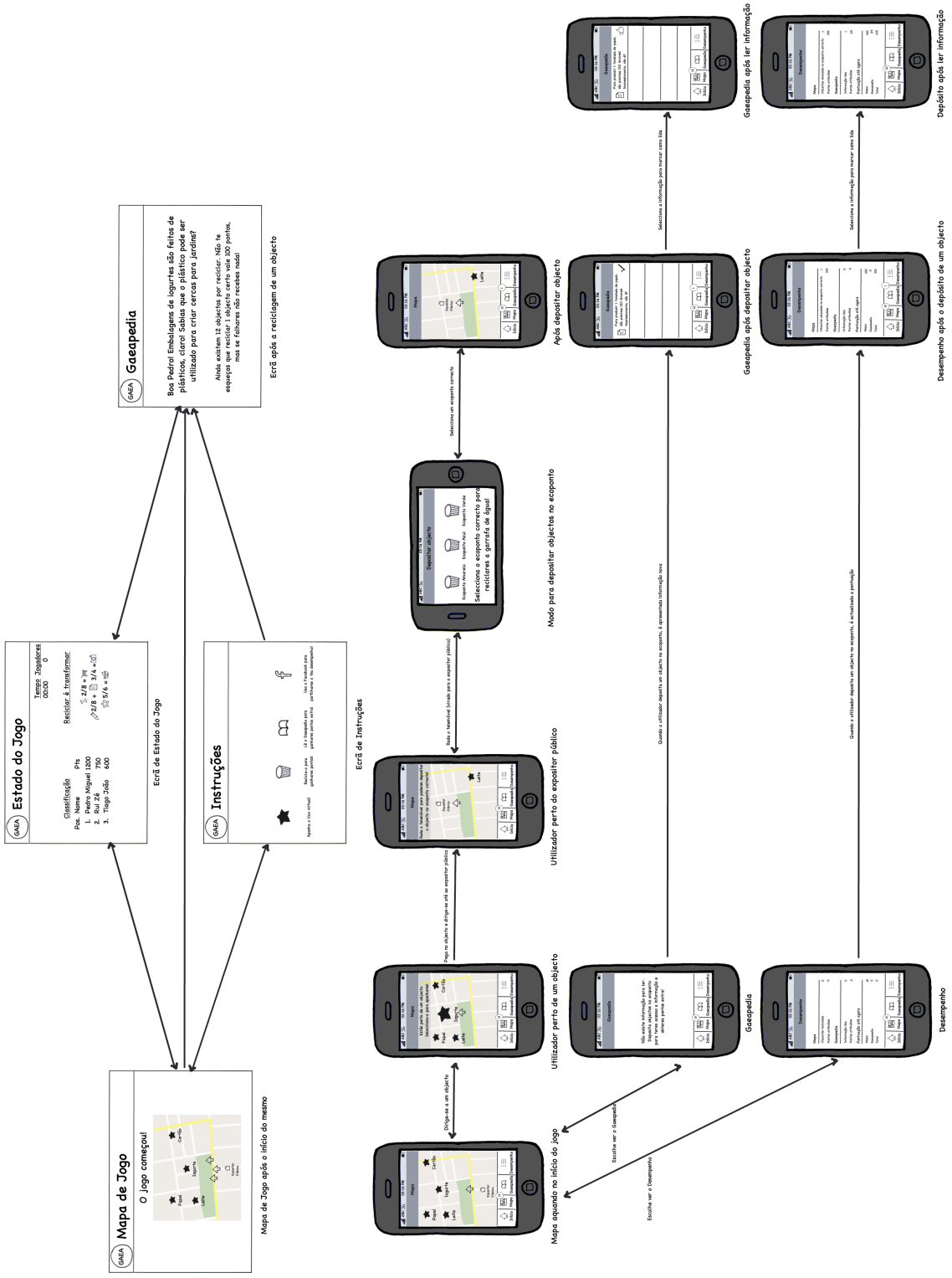
8. Annexes

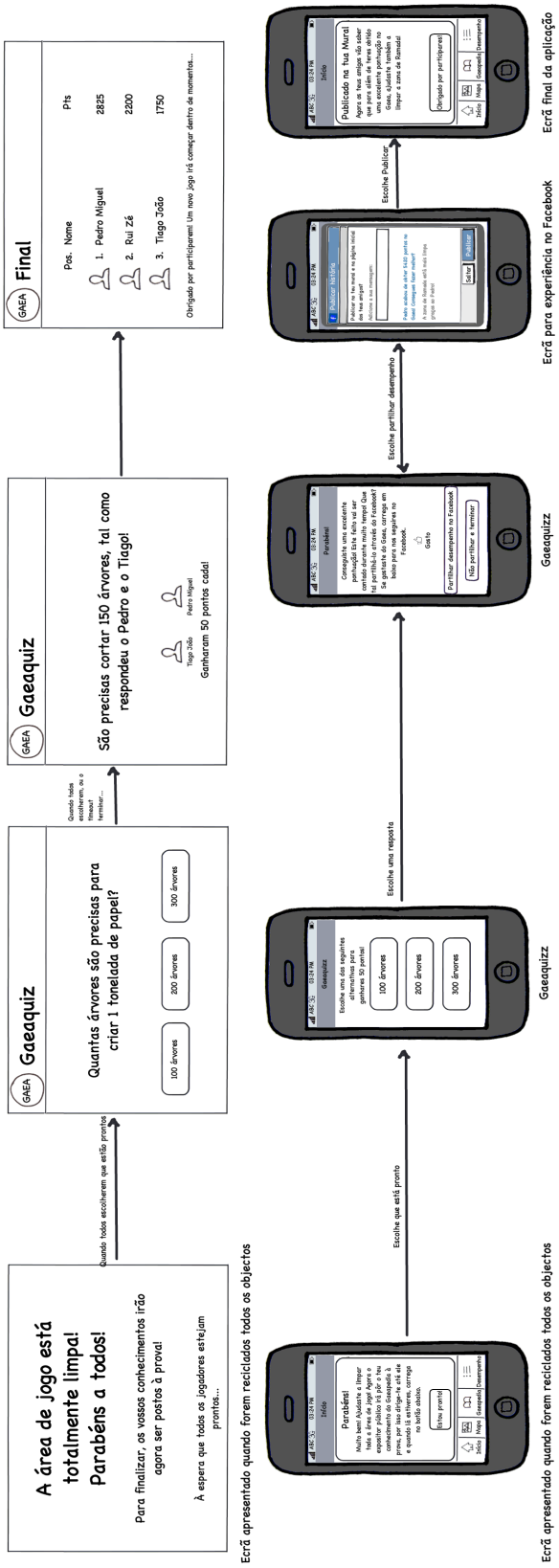
Registration Phase Storyboard



Recycling Phase Storyboard



Quiz Phase Storyboard



Usability Questionnaire

Gaea
Questionário de Avaliação

Este questionário tem por objectivo avaliar a usabilidade da interface do Gaea. Este sistema permite a interacção entre dispositivos móveis e expositores públicos e pretende informar, consciencializar e persuadir os utilizadores a adquirem hábitos de reciclagem.
Todos os dados recolhidos são confidenciais e não serão utilizados para qualquer outra finalidade.

1. Dados Pessoais

1.1. Idade:

_____

1.2. Sexo:

❑ Masculino ❑ Feminino

1.3. E-mail (utilizado **unicamente** para um questionário posterior):

_____

3. Grau de Instrução

❑ Doutoramento/Pós-Doutoramento ❑ Mestrado/Pós-Graduação ❑ Licenciatura (completa)

❑ Licenciatura (incompleta) ❑ Ensino Secundário ❑ 3º Ciclo do Ensino Básico

❑ 2º Ciclo do Ensino Básico ❑ 1º Ciclo do Ensino Básico ❑ Autodidacta

4. Novas Tecnologias

4.1. Está familiarizado com as novas tecnologias?

❑ Sim ❑ Não

4.2. Que tipo de tecnologias utiliza?

❑ Computador ❑ Diariamente ❑ Semanalmente ❑ Mensalmente ❑ Raramente	❑ Telemóvel ❑ Diariamente ❑ Semanalmente ❑ Mensalmente ❑ Raramente
❑ Consolas de jogos ❑ Diariamente ❑ Semanalmente ❑ Mensalmente ❑ Raramente	❑ Internet ❑ Diariamente ❑ Semanalmente ❑ Mensalmente ❑ Raramente
❑ Outra. Qual? _____ ❑ Diariamente ❑ Semanalmente ❑ Mensalmente ❑ Raramente	

Gaea
Questionário de Avaliação

Responda às seguintes questões fazendo **um círculo em volta do número** que melhor representa a sua opinião acerca da aplicação que acaba de experimentar.

5. Aspectos Gerais

	Discordo				**Concordo**
5.1. Gostei de utilizar o Gaea.	1	2	3	4	5
5.2. É fácil aprender a usar o Gaea.	1	2	3	4	5
5.3. É fácil utilizar o Gaea.	1	2	3	4	5
5.4. Inicialmente o Gaea pareceu-me complexo.	1	2	3	4	5

6. Usabilidade e Facilidade de Uso

	Discordo				**Concordo**
6.1. A aplicação requer poucos passos para realizar cada tarefa.	1	2	3	4	5
6.2. A aplicação ajuda-me a executar facilmente as tarefas pretendidas, não me deixando dúvidas sobre as mesmas.	1	2	3	4	5
6.3. Consigo usar a aplicação sem recorrer a ajuda exterior.	1	2	3	4	5
6.4. O *feedback* fornecido pela aplicação foi útil.	1	2	3	4	5
6.5. A aplicação respondeu rapidamente às diversas acções.	1	2	3	4	5

6.6. Classifique a facilidade de execução das seguintes funcionalidades:

	Difícil				**Fácil**	**Não executou**
a) Executar o registo na aplicação.	1	2	3	4	5	❑
b) Utilizar o Facebook (para identificar-se e publicar desempenho e experiência no Mural).	1	2	3	4	5	❑
c) Ler as instruções.	1	2	3	4	5	❑
d) Navegar no mapa (acções tal como deslocar, fazer Zoom In/Zoom Out ou usar bússola).	1	2	3	4	5	❑
e) Apanhar um objecto.	1	2	3	4	5	❑
f) Reciclar um objecto.	1	2	3	4	5	❑
g) Marcar uma informação no Gaeapedia como lida.	1	2	3	4	5	❑
h) Responder ao questionário.	1	2	3	4	5	❑

7. Reciclagem

7.1. Acha que os tópicos abordados pelo Gaea são importantes?

❑Sim ❑Não

7.2. Aprendeu com a informação disponibilizada pelo Gaea?

❑Sim ❑Não

7.3. A experiência de utilização do Gaea sensibiliza para a necessidade de reciclar?

❑Sim ❑Não

7.4. Antes de utilizar o Gaea já efectuava reciclagem?

❑Sim ❑Não

7.4.1. Caso tenha respondido que **não**, acha que o Gaea motivará uma mudança da sua atitude e comportamento relativamente a este tópico?

❑Sim ❑Talvez ❑Não

7.4.2. Caso tenha respondido que **sim**, sente-se mais motivado a continuar a efectuar reciclagem?

❑Sim ❑Não

8. Envolvimento Emocional

Escolha as expressões que melhor definem a sua experiência na utilização do Gaea.

❑Agradável	❑Simples	❑Cansativa	❑"Stressante"
❑Frustrante	❑Divertida	❑Imersiva	❑Inspiradora
❑Estimulante	❑Aborrecida	❑Irritante	❑Irrelevante
❑Complexa	❑Inovadora	❑Entusiasmante	❑Útil
❑Confusa	❑Atractiva	❑Motivante	❑Viciante

9. Sugestões e Comentários

Muito obrigado pela sua colaboração.

Evaluation Questionnaire

Gaea
Questionário de Avaliação

Este questionário tem por objectivo avaliar o comportamento e atitudes dos utilizadores um determinado período de tempo após utilização do Gaea.
Todos os dados recolhidos são confidenciais e não serão utilizados para qualquer outra finalidade.

1. Facebook

1.1. Com que frequência utiliza o Facebook?

❑ Diariamente ❑ Semanalmente ❑ Mensalmente
❑ Raramente ❑ Não utilizo o Facebook

1.2. Utilizou o Facebook no Gaea?

❑ Sim ❑ Não

1.2.1 Caso tenha respondido que **não** utilizou, porque é que não o fez?

❑ Porque não estava a utilizar o meu próprio telemóvel
❑ Por motivos de confidencialidade
❑ Não tenho conta no Facebook
❑ Porque a autenticação na aplicação era demorada
❑ Outra razão. Qual? _____

Responda às seguintes questões fazendo **um círculo em volta do número** que melhor representa a sua opinião.

2. Reciclagem

	Discordo				**Concordo**
2.1. A experiência de utilização do Gaea chamou-me à atenção para a necessidade de reciclar.	1	2	3	4	5

	Diminuiu				**Aumentou**
2.2. A minha motivação para efectuar reciclagem desde a utilização do Gaea...	1	2	3	4	5

Muito obrigado mais uma vez pela sua colaboração.