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Changing Environmental Behaviors through Smartphone-based Augmented Experiences

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Resumo

Com o recurso a tecnologias persuasivas é possível induzir alterações nas atitudes ou comportamentos, mesmo de indivíduos que outras estratégias de persuasão não conseguem atingir de modo eficaz. Além disso, este tipo de tecnologia pode ser aplicado em inúmeras áreas como saúde, educação, finanças, economias baseadas na internet, entre outras.

Apesar da persuasão poder ser vista como algo negativo, ao ser utilizada para servir interesses do persuasor em detrimento dos interesses do persuadido, este trabalho visa atingir um objectivo comum e partilhado: a alteração do comportamento das pessoas em relação ao ambiente.

Uma boa parte da população ainda não está consciencializada para os problemas de sustentabilidade que o nosso planeta enfrenta, pelo que é necessário alertar as pessoas em relação à temática e, ao mesmo tempo, persuadi-las a mudarem o seu comportamento e a adquirirem atitudes pro-ambientais.

Assim, nesta dissertação foi conduzido trabalho que predispõe-se a alertar os cidadãos para esta problemática de uma maneira divertida e imersiva, recorrendo aos dispositivos móveis, mais propriamente *smartphones*, e à tecnologia de realidade aumentada que foi usada para a criação de um *scanner* ambiental. Este *scanner* ambiental permite oferecer ao utilizador uma visão elucidativa acerca do ambiente que o rodeia, evidenciando as ameaças ambientais.

Além da realidade aumentada, são ainda reforçadas positivamente as acções pro-ambientais utilizando um sistema de recompensas e uma mascote virtual que irá interagir e motivar o utilizador. Criou-se ainda uma forma de propagação rápida através das redes sociais, permitindo assim levar rapidamente o efeito persuasivo a um grande número de utilizadores.

Por fim, foi efectuado um estudo para aferir o sucesso do trabalho efectuado na alteração de comportamentos ao nível da problemática ambiental, e para avaliar a influência da realidade aumentada e do reforço positivo na alteração de comportamentos e atitudes pró-ambientais.

Palavras chave: Dispositivos Móveis, Tecnologia Persuasiva, Realidade Aumentada, Interfaces de Utilizadores, Consciência Ambiental.

Abstract

The use of persuasive technologies can induce changes in attitudes or behaviours, even in individuals that other strategies of persuasion can not reach effectively. In addition, this type of technology can be applied in numerous areas such as health, education, finance, e-business, among others.

Although persuasion can be seen as something negative, being used to serve the interests of the persuader rather than the interests of the persuaded, this work aims to achieve a common and shared goal: to change people's behaviour towards the environment. A significant part of the population is still not aware of the sustainability problems that our planet is facing, so it is important to inform people about the theme while persuading them to change their behaviour and acquire pro-environmental attitudes.

In this dissertation, work was conducted to alert citizens to this issue in a fun and immersive way using mobile devices, more specifically smartphones, and augmented reality technology that was used to create an environmental scanner. This scanner provided the user with informative insight about the surrounding environment, while highlighting the environmental threats.

In addition to augmented reality, pro-environmental actions were positively reinforced using a reward system and a virtual character that interacted and motivated the user. A form of rapid spread through social networks was also created, allowing the persuasive effect to quickly reach a large number of users.

Finally was performed a study to assess the success of the work done in changing behaviour towards environmental issues, and to study the influence of augmented reality and positive reinforcement in the changing of behaviours and acquisition of pro-environmental attitudes.

Keywords: Mobile Devices, Persuasive Technology, Augmented Reality, User Interfaces, Environmental Awareness.

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1 Introduction

This dissertation presents and documents the work done in terms of research, implementation and study of a persuasive technology for environmental awareness. In this thesis, an application providing augmented reality experiences through mobile devices was created and used to persuade people to change their behaviours and attitudes towards a better environmental consciousness.

This research was conducted in the scope of DEAP project (Developing Environmental Awareness with Persuasive Systems - PTDC/AAC-AMB/104834/2008, <http://deaproject.com>), which includes members of New University of Lisbon and the University of Évora. DEAP project is funded by the Fundação para Ciência e Tecnologia.

1.1 Motivation

In the recent years the modern society has evolved in many aspects but people still lack routines and behaviours that support and help the environment. The concept of sustainability is usually ignored, or simply unknown, by many people on developed nations meanwhile consumption of natural resources far exceeds the planet capacity to produce them, more exactly 50 per cent more [1]. This alarming rate of consumption is not only responsible for the population decline of many Earth species, but is also putting the human race on a “ecological debt” which will not be payable unless we restore the balance between our natural resources consumption and the planet’s ability to renew them [1].

This *balance* or *equilibrium* can be achieved in a great number of ways, some of them are well known to the general public and can be achieved by anyone willing to do so:

- Recycling: the most popular way of sustainable behaviour is the process of turning waste into new useful materials.
- Energy saving: one of the simplest ways to help the environment that can be achieved with better home energy management or with micro-regeneration and insulation equipment.
- Water saving: similar to the previous point, is achieved by making a responsible usage of the water resources.
- Buying Eco-Products: give preference to products that have good rates of energy efficiency or are produced with recycled materials.
- Careful use of personal transport: attempt to reduce CO₂ emissions by using more fuel efficient vehicles, like hybrid cars, resort to public transports as a means of transportation and avoid using personal car for short trips.

Putting into practice the previous points will not only help us to re-establish the *balance* in natural resources consumption but will also drastically lower pollution rates. Unfortunately these sustainability measures are yet to become widely adopted by people even though some give instant rewards (e.g. energy saving can save a great amount of money in monthly expenses).

Thankfully, times are changing and the younger generations are increasingly aware of sustainability problems and in countries like United States of America and Canada young adults are willing to change their behaviour based on sustainable values [2]. Also, in an informal study conducted by our group [3], results showed that participants were willing to change their behaviour towards the environment and that persuasive systems are likely to be accepted as an enabler to do so. Thus, the creation of applications or technologies to motivate and drive people to participate in environmental preservation activities is an area worth exploring.

To better understand this ambition, first we need to fully understand the concept of Persuasive Technology. One of the most important contributors to this field of research, B.J. Fogg, defines persuasive technology as “any interactive computing system designed to change people’s attitudes or behaviours” through persuasion and social influence without using coercion or deception [4].

This type of technology has been used in recent years in fields like health, finances, relationship, self-improvement and e-business [4]. On the pro-environmental front we have been exploring eco-feedback technologies, persuasive technologies that provide feedback on individual or group behaviours to increase environmental awareness and consequently reduce their environmental impact [5].

In the research field of Human-Computer-Interaction, persuasive technology was mostly focused on interactive computer experiences (e.g. websites and video-games). However, more recently, with the appearance of a plethora of new and exciting smart-phones, tablets and other mobile devices arose the possibility of exploring persuasive technology on mobile devices. This happened due to the immense popularity acquired by devices like the iPhone® that contains an extensive set of functionalities, like Wi-Fi, Bluetooth, MP3 player, Cloud capabilities, Camera, GPS, 3G and a library of applications with many different uses and advantages. Nowadays, mobile devices are probably the most ubiquitous type of technology and people tend to use them in many different ways like the recent success of App Store® indicates.

With all features, capabilities and qualities of the mobile devices, previously mentioned, it is possible to create applications that can motivate and drive people to change their environmental behaviours. Moreover, given the wide success of this type of devices, almost everyone can be reached. To achieve this we have to provide the user with something that is not only informational but also engaging and immersive, making him or her follow the application recommendations and advices.

Creating an engaging experience is possible applying the notion of video game: an electronic game that involves interaction with a user interface and generates visual feedback according to the user's actions on a visual display. On top of that, a new layer of immersion can be added thanks to augmented reality: a technology which allows computer generated virtual imagery to exactly overlay physical objects in real time [6].

Although augmented reality technology had been developed over forty years ago [6], only in recent years the possibility to implement it on mobile devices emerged, thanks to the addition of cameras and potent image processing hardware.

With persuasive technologies on mobile devices in conjunction with augmented reality techniques it is possible to provide new and amusing ways of interaction to a broad audience, stimulating and driving them to become more aware of sustainability problems that our planet is facing, while persuading them to adopt pro-environmental behaviours in favour of a better future.

1.2 Description and Context

In our everyday life we are confronted with situations, which directly damage our planet's sustainability sometimes without even noticing them (e.g. vehicles' CO₂ emissions, water and energy waste). Making people aware of this kind of situation is crucial to change their perspective about this issue, this will be the main approach of this thesis.

People need to understand that Earth's resources will not last forever and that we, as the dominant specie in the planet, have the obligation to preserve them as long as we can. It is an hard process that many people do not even try to accomplish, because they do not see the immediate results of their actions. We need to change this idea by giving people feedback of some of their everyday actions, in terms of environmental hazard, demonstrating them possible future consequences and subtly motivating them to change some of their routines with the purpose of avoiding such consequences. Promoting the gains of a better environmental consciousness is also a possibility by showing people what they could gain if they adopt more sustainable values.

Taking this approach in an interactive manner is a great way to get more people involved, rewarding them every time they complete some tasks of interest regarding this issue. This can be achieved by providing positive feedback and encouraging them to share they experiences through social networks bringing even more people "to the table" and making possible for them to compare results and performances.

It is unrealistic to think that everyone will change their behaviours day over night but if we can make some change others will follow thanks to social influence, peer pressure and divulgation of this issue [9].

1.3 Main Contributions

The main contributions of this thesis are:

- Research on persuasive technology in a pro-environmental domain using augmented experiences;
- Provide a prototype scanner to analyse environmental threats on people's everyday life;
- Study of the impact of these type of human-computer interaction augmented experiences on people's pro-environmental behaviour;
- Analysis of the impact of positive reinforcement in this type of applications;
- Study of the persuasive effect present on an avatar-like induced motivation.

This work also led to a publication at ACE 2012, which will be held in Kathmandu, Nepal, between 3 and 5 of November 2012 [60].

1.4 Document Organization

The remainder of this thesis is organized on the following order:

- ✓ Chapter 2: addresses the state of the art related to the concepts involved on this thesis.
- ✓ Chapter 3: describes the design process behind the prototype as well as user and task analysis.
- ✓ Chapter 4: this chapter presents the paper prototype developed along with the users' tests associated with it.
- ✓ Chapter 5: presents the development and implementation of the final prototype, as well as the conducted usability evaluation and impact tests.
- ✓ Chapter 6: the final content chapter presents the conclusions of the work done in the thesis and a blueprint for the future work.

2 Related Work

To understand the issues presented in this thesis, it is important to know and address the state of the art of the topics related to it. The literature review will be presented in this chapter accordingly to the following structure: Persuasive Technology, Mobile Human Computer Interaction, Augmented Reality and Image Processing - Object Detection.

The first topic, Persuasive Technology, presents how computers can be designed to change people's attitudes or behaviours. Concepts such as Captology will be introduced as well as persuasion through mobile devices, the future most important platform to change human behaviour [12], which will be given special attention due to the proposed solution context. Another important topic for this thesis, persuasion through Social Networks, will be also addressed.

In the second topic, Human Computer Interaction in a mobile environment will be presented. Since the application was developed having a smartphone in mind, it is important to take into account particularities of interaction between people and mobile devices, like interface design, context awareness, among others.

Augmented Reality (AR) concepts and how this type of technology can be used on a persuasive environment will be considered in the third topic. To fully understand the implementation done in this thesis, it is essential to mention the basic principles of AR, how they have been implemented in recent years and the contributions that this kind of technology provides to persuasive systems.

Finally, the fourth topic addresses the work related to Object Detection on Image and Video Processing. This issue is important for implementation of the vehicle dynamic detection feature of the prototype application. This section will present research works on object detection.

2.1 Persuasive Technology

Persuasive Technology is generally defined as technology that is designed and used to change people's behaviours and attitudes without coercion or deception. Its application in the field of Human-Computer Interaction (HCI) is quite diversified from Health, to Commerce, Safety, Management and other fields [4]. Pro-environmental applications using Persuasive Technology are also being studied, in projects like [13] which promotes water conservation in public and private spaces using Low-Cost Water Flow Sensing and Persuasive Displays.

In 1996, B.J. Fogg coined the term Captology as a new word that described the study of computers as persuasive technologies [14], representing the area where technology and persuasion overlap (figure 2.1).

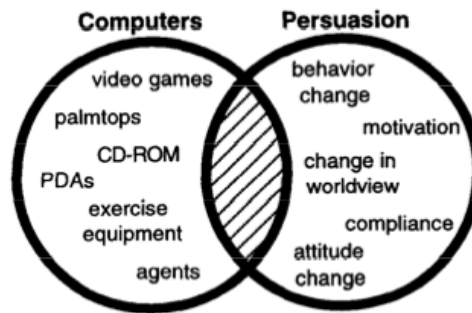


Fig. 2.1 - Captology describes the shaded area

Captology focuses on attitude and behaviour changes resulting from Human Computer Interaction instead of changes through computer-mediated communications, i.e., it investigates how people are persuaded when interacting with computers rather than through them. It is also important to point out that Captology does not include unintended outcomes from persuasive technology products. Instead, it focuses on planned persuasive effects or behaviour changes intended by their designers. Also regarding intentions, Captology does not focus on exogenous intent, but rather on endogenous persuasive intent built into a product [4].

To better identify, analyse or design persuasion opportunities it is crucial to understand the two levels of persuasion, macro and micro. Macrosuasion, persuasion on a macro level, usually refers to products that were created with the solo intent of persuasion, like the proposed solution of this thesis. Microsuasion, persuasion on a micro level, usually refers to products that include smaller persuasive elements, but do not have an overall intent to persuade.

Persuasion, in the context of Captology, has six main advantages over typical human persuaders [4]:

- Computers are Persistent: computers do not get tired, frustrated or discouraged and do not have physiological needs, they can work all day long, looking for the right moment to persuade.
- Greater anonymity: computer program interactions can help to preserve the anonymity of the user, something that is very important in some persuasive activities.
- Computers can manage huge volumes of data: the ability to store, access and manipulate great volumes of data gives interactive technology the potential to be more persuasive than human beings.
- Use many modalities to influence: computer systems can present information in a greater variety of modes than human beings.
- Scale Easily: when demand increases, the persuasive technology can grow quickly and with relative ease. Persuasive technology experiences can be replicated and distributed while working exactly as the original.

- *Ubiquity*: persuasive technology has the ability to be almost everywhere.

2.1.1 Computers as Persuasive Technology

Computers can play three different persuasive roles: Tool, Media, and Social Actor. For a better understanding of this concept, Fogg proposed the functional triad (figure 2.2), a framework that illustrates every possible computer role, making it easier to design or study computers as persuasive technology [4].



Fig. 2.2 - The Functional Triad

Computers as Tools

Computer systems were essentially created to serve as tools to help human beings to complete certain tasks. This computer role refers to the first corner of the functional triad. In Captology, this persuasive role can make the target behaviour easier to achieve, leading people through a specific process or motivating them by performing calculations or measurements.

In short, a persuasive technology tool is a product created or designed to change attitudes and behaviours by making the desired outcomes easier to achieve [4]. There are several examples of applications of this kind of technology, such as: water conservation promotion [17]; a real-time feedback of a device usage for a better energy management [18]; motivate people to do some physical exercise [19].

There are seven types of persuasive technology tools, and they can be combined in a product to achieve a desired outcome:

- *Reduction*: use computing technology to simplify a complex behaviour into simple tasks. This process increases the benefit/cost ratio of the behaviour and persuades users to perform a behaviour that otherwise they would feel reluctant to do so [4]. Amazon's "1-click ordering" option is a good example of this type of persuasion.
- *Tunneling*: use computing technology to lead users through a predetermined process or experience, exposing them to information and activities they would not see or engage otherwise, thus providing opportunities to persuade [4].
- *Tailoring*: the basic principle behind this type of persuasion is that information will be more persuasive if it is tailored according to the individual's needs, interests, personality, usage

context or other factors relevant to him or her [4]. The simple perception of tailoring can be persuasive because if people believe messages are tailored they tend to pay more attention and process the information more deeply.

- *Suggestion*: computing technology will have more persuasive power if it intervenes at the right time, providing suggestions to encourage a certain behaviour. As an example, in the study [15] one of the most accepted persuasive interfaces was the *EcoSpeedometer*, a display seamlessly integrated into the traditional speedometer providing visual feedback whether the driver is driving fuel-efficiently at the moment (green colour) or if the current driving style is wasteful (orange colour).
- *Self-monitoring*: this type is based on the principle of applying computer technology to eliminate or mitigate the tedium of tracking performance or status. This kind of automatic process frees people of having to monitor themselves, helping them to achieve predetermined goals or outcomes [4]. This type of persuasive technology is often found on heart rate monitors and other fitness products.
- *Surveillance*: persuasion through observation. Using technology to observe and gather information about others increases the likelihood of achieving the desired outcome [4]. It can be designed to motivate people behaving in a certain way through the promise of rewards, although it is often used in the opposite way, changing behaviours through the threat of punishment, which turns surveillance in the less noble approach of persuasion.
- *Conditioning*: computerized system that uses principles of operant conditioning to change behaviours by using positive reinforcement to shape complex behaviours or increase the instance of a behaviour. In the pilot study presented in [13] all participants interpreted the green light of the ambient display to be a positive reinforcement, while red implied negative behaviour (wasteful water usage). This reinforcement successfully reduced water usage by nearly 2 gallons per shower.

Tailoring, tunneling, and reduction tend to be the most used ways for persuasion to support accomplishing one's primary task, according to the analysis of peer-reviewed full papers published at the first three International Conferences on Persuasive Technology [16]. When designing, analysing or using persuasive technology, the degree of intervention must be considered and in many cases effective persuasion requires more than one tool type. To help choose the right tools it is good to keep in mind their natural synergies.

Computers as Media

Computers can also act as Media, as shown at the bottom corner of the functional triad. In this particular role there are two types: symbolic (when symbols are used to transmit information) and sensory (when sensory information is provided). Computers in this role allow people to explore the cause-and-effect relationships, motivate them with vicarious experiences and help them rehearsing a behaviour. This happens by simulating experiences that mimic the real world ones, or they can simply create hypothetical worlds that may be perceived as real [4].

Good examples are two projects developed with funding from the U.S. military, *Tactical Iraqi* and *Virtual Iraqi*. The first has the objective to facilitate the learning of spoken Arabic to assist soldiers in volatile tactical situations. The second is intended to trigger powerful memories in combat veterans suffering from Post-Traumatic Stress Disorder (PTSD), persuading them to develop compensatory mechanisms, decreasing the effects of PTSD [20].

There are three simulation categories relevant to persuasive technologies that offer insight into computers as persuasive sensory media:

- *Cause-and-effect scenarios*: this type of simulation enables users to immediately see the consequences (effect) of their input actions (cause) and the link between the two. Moreover, cause-and-effect simulation also provides a safe environment for users to explore and experiment persuading in subtle ways without being intrusive [4].
- *Environment*: similarly to the previous category, environment simulation allows the user to experiment behaviours in a safe place but in this case through the creation of virtual environments. This “virtual worlds” enable the rehearsal of behaviours, control exposure to frightening situations, and also allow users to adopt the perspective of another person. Environment simulation can also be persuasive by rewarding people for a target behaviour, making them increase the instances of that behaviour or attitude, and can be seen in Tectrix VR Bikes [4]. Studies have been also conducted to explore this technology as an important and reliable technique for fighting the fear of flying [21].
- *Object*: the opposite approach of the previous category, object simulation is based in real world settings. This makes object simulation fitting to the context of the user’s everyday life, less dependent on imagination and with the ability to display the clear impact of a behaviour or attitude on the user’s life [4]. The mentioned characteristics turn this simulation type into a important persuader as can be seen in the Baby Think It Over infant simulator, which simulates a baby and the attention he or she requires, making teenagers who test it more aware of the parenting responsibilities [4].

The increase of processing power and networking gave computers the ability to function as Media taking advantage of simulation, which can be a powerful source of persuasion in interactive technology.

Computers as Social Actors

The last corner of the functional triad is Computers as Social Actors. In this role users respond to computers as if they were living beings even when they are not given explicitly anthropomorphic interfaces. This allows computers to persuade by rewarding people with positive feedback, modelling a target behaviour or attitude and providing social support.

There are several examples of this, in [22] children create an avatar who guides them, recommends the tasks the clinician has proposed for them to carry out, and also provides them with rewards in order to improve childhood obesity treatment. In another study, an empathic virtual human was created to encourage and persuade users, with results showing that persuasion conducted by the virtual human could increase their completion rate of exercises [23].

Another work used the iCat to persuade people to save energy, and results indicated that participants who received social feedback consumed less electricity than participants who received factual feedback [24].

In this role computers persuade by giving a host of social cues that triggers social responses from the human. The primary types of social cues are presented bellow [4]:

- *Physical*: computer products can use physical attributes (face, eyes, body, movement) to convey social presence to the user, but having this attributes presented in an attractive way provide better persuasive results. This happens because computing technology that is visually appealing to the target user is more likely to persuade him, something often found in video-games that use graphical design to persuade people to play them.
- *Psychological*: this type of cues makes the user think that the computer product has emotions and a personality, making people sympathize with it. Psychological cues can be very persuasive by themselves, but the similarity principle, which states that people are more easily persuaded by computer products that are similar to themselves in some way, should always be taken into consideration when designing this kind of technology.
- *Language*: computers' "talking skills" can also be used to convey social presence thus persuading users. There are several ways of doing that, but praising is one of the most effective ways to do so. Praising through visual objects or sounds can lead people to be more open to persuasion.

- *Social Dynamics*: by following the rules people use to interact with each other, computing technology can convey a social presence and persuade. This can be achieved by applying the principle of reciprocity, which states that people will feel the need to reciprocate when someone has done them a favour [9]. The same principle applies to a computer product.
- *Social Roles*: computer products can gain enhanced persuasive powers when they play a social role of authority. This happens because people expect authority figures to lead them, make suggestions and provide helpful information.

Despite of the persuasive power of the social cues presented above, it must be taken into account the user's disposition to interact (even if it occurs with a virtual character or the computer) and the fact that repetition is something that can make an experience frustrating.

2.1.2 Mobile Persuasive Technology

Mobile devices are the “next big thing” and according to B. J. Fogg we are “on the cusp of a persuasive revolution”. In the future everyone will have a mobile device and will be targeted by its persuasive capabilities. To explain how mobile devices will reign in the persuasion universe Fogg proposes three metaphors: a heart, a wristwatch and a magic wand [12].

The heart metaphor means that people love their mobile devices, specially their mobile phones. People spend more time with their mobile phone than with any other object or person, developing a mobile-human relationship. This relationship is the most personal, intensive and lasting of all relationships making people feel trust, competence and delight. Designers should create interactions that provide the same feelings opening a door for persuasion.

By wristwatch Fogg means that mobile devices are always with us. This is very important, because it gives them the ability to leverage the principle of kairos (presenting a message or suggestion at opportune moments [4]) and use it to persuade the user. The omnipresence of mobile devices can also be explained through three roles:

- *Concierge*: mobile devices can act as a virtual concierge offering information or guidance every time the user needs it (e.g. searching for a hotel to spend the night). The information conceived can be designed to persuade the user taking advantage of the principle of mobile loyalty (mobile applications that are perceived to serve the owner's desires first, rather than those of an outside party, will have greater persuasive power [4]).
- *Coach*: by tracking the user's goals and context, mobile devices can act as coaches, reacting in the right time according to the information gathered. For example, when the user goes to work the mobile device could advice her to take the bus instead of her private vehicle.

- *Court jester*: the last role for a mobile device consists in the ability to amuse the user, providing funny information, games or social activities. This ability can be used when the user is bored or wants to kill some time, and while he is having fun doing so opportunities to persuade him arise.

The last metaphor, the magic wand, represents the mobile device's "magic" capabilities. Lets see Apple's iPhone® for example, it supports normal phone calls, video phone calls, short messages, multimedia messages, can act as a MP3 player, a video player, it has GPS, compass, a touchscreen, a gyroscope, an accelerometer, two cameras (one with a flash LED) and Wi-Fi. Many persuasive experiences can be created with such advanced technology (e.g. use the GPS to transmit audio messages based on the user location).

There are several examples of possible applications of mobile persuasion. B.J. Fogg and Enrique Allen presented ten ways for texting to improve health behaviour [25]. The ten ways were grouped in five categories: sending info to users, gathering info from users, user questions & expert response, people-to-people connection and transactions. To illustrate the first category for instance there is "Reminding People" that sends text messages to the users' cell phones reminding them about their personal goals (e.g. drink water each morning or attend to an appointment at the health clinic).

MyFoodPhone [26] was created to monitor what people eat and help them modify their bad eating habits. The service operates in the following steps:

1. Take a Snapshot: before eating or drinking, users would take a picture with their mobile device.
2. Send the photos: after the first step, all photos would be sent to the food journal to serve as a log with detailed information of all the user's meals.
3. Feedback: on a regular basis a dietitian would provide video feedback concerning the information presented on the user's food journal to help him stay motivated and increase the likelihood of achieving his goals.

A MFP Community was created to reinforce the MyFoodPhone service, where people with similar interests could share information and support each other in a fun and efficient way.

There are more applications of mobile persuasion, like promoting youth sexual health [27], use mobile devices to boost physical activity [28] or persuade users to conserve energy [29]. These show the positive impact that mobile persuasion can have in everyone's lives.

2.1.3 Persuasion Through Social Networks

Social networks appeared with evolution of the web. These networks enable people to establish social links with other people according to their motivations and interests and highly depend on being able to hold the users attention and desire to continue participating.

The best example of a successful social network is Facebook, with more than 750 million users (50% being active users). The average user has 130 friends, creates 90 pieces of content and is connected to 80 community pages, groups and events [52].

Based on Facebook, Xingxin Liu presented a new model [38] for online persuasion called “Triangle User Lock” (figure 2.3). The model identifies three fundamental elements for user interaction: content, community of users who share common interests, and activities for users to join or interact.

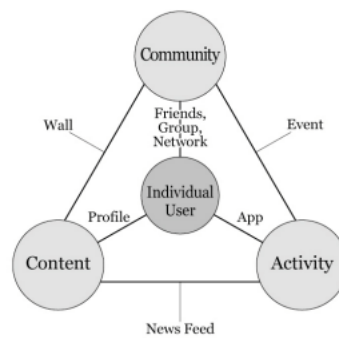


Fig. 2.3 - Triangle User Lock

Facebook succeeds in user engagement by providing easy self-perception and rich social capitals through seamless interactions among content, community and activity [38]

In the case study [45] Fogg presents a video marketing campaign on Facebook showing recommendations for effective video persuasion design, focusing on a new kind of video player presentation, showing how social networks can be used to persuade a great number of people.

2.2 Mobile Human Computer Interaction

Mobile Human Computer Interaction (MHCI) is a particular case of Human Computer Interaction (HCI), where the interactions between the users and mobile devices are studied. Although some guidelines of HCI (e.g. Schneiderman’s Eight Golden Rules [39]) also apply to MHCI, there are specific design decisions that have to be made based on the mobile nature of the devices such as screen size, lack of button interfaces (touch-based devices) or concerning the mobile devices’ heterogeneity.

When designing for mobile devices common problems arise related to three main issues: utilizing screen space, interaction mechanisms and design at large [40]. Each main area has two sub-areas (Table 1):

Utilizing Screen Space

Screen Space in general: problems connected to different layout challenges on small screens.

Flexible user interfaces: problems related to changing the layout dynamically at runtime - both the information to be presented and the environment in which it should be presented may change.

Interaction Mechanisms:

Handling input: problems associated with entering information more efficient and/or with less probability for entering incorrect information.

Not using the stylus: problems correlated with entering information in situation when it is not possible/convenient/desired for the user to use a stylus.

Design at large:

Guidelines: design guidelines on different levels of generality.

“Difficult to understand”: problems connected to providing understanding of what is happening when a mobile application performs functionality that can be difficult to understand for the end user – usually functionality that is specific for mobile applications.

Main Problem Area	Sub-Area	Individual Problems / UI Design Patterns
Utilizing Screen Space	Screen space in general	Presenting elements in lists Principles and mechanisms for grouping information Mechanisms for packing information Mechanisms for grouping information Horizontal scrolling
	Flexible user interfaces	Handling crowded dialogs when software keyboard is shown/hidden Supporting switching between portrait and landscape mode UIs that should run on equipment with different screen size Presentation based on models or data – how to do this on a small screen UIs that facilitate switching between portrait and landscape mode
Interaction Mechanisms	Handling input	Mechanisms for entering text Mechanisms for entering numerical data Multimodal input Order entry Controlling input cursor from an application
	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 Design guidelines for data base applications, including automatically generated user interfaces Design that supports branding, is aesthetic, and utilize screen space optimally Solutions for searching large amounts of data Visually coding of entry fields to mark editability (must, may, may not) Standard solutions vs. usable tailored solutions
	Difficult to understand	User interaction during synchronization User interaction during long-lasting operations User interaction for log-on/log-off

Table 2.1: Identifying Main Problem Areas and Problems [46]

Problems referred in the previous table need to be addressed when designing user interfaces for mobile applications in order to preserve interface usability and functionality. Something that is usually affected by these problems is information visualization.

People are used to rely on visualizations to better understand problems they have to solve and to take better decisions in less time. Thanks to the continuous increase in power and graphics capabilities of computers, visualization has a growing role in almost every domain of computer applications, ranging from business to medicine, from engineering to science. Unfortunately bringing visualization techniques to mobile devices is impossible following a trivial porting approach from desktop computers [40].

To help resolve information visualization problems Chittaro proposed a sort of checklist that highlights the major steps one should go through to better design mobile visualizations [40]:

- *Mapping*: in this step there are two base principles, first a precise mapping among data objects and relations, and second, visual objects and relations need to be defined and followed consistently throughout the application. This aspect has to be resolved in a way that conceptually important aspects are also made perceptively important.
- *Selection*: this step refers to relevant data for a certain task. Visualizing insufficient data can lead users to take suboptimal or wrong decisions, and presenting users with unnecessary data will make it more difficult for them to reason about the problem at hand. The selection problem is crucial in mobile visualizations, because limited screen space requires information to be chosen wisely.
- *Presentation*: in this step the problem of too much data for too little display area is discussed. The application can become ineffective because the display is too little to show everything, so a convenient way to visualize the information on the available display area is needed.
- *Interactivity*: is very important to provide the user with tools to interact with the visualization to increase his or her engagement towards the observed data and enhance his exploration abilities.
- *Human Factors*: users must be able to quickly, easily and correctly recognize and interpret displayed data. It is therefore important to take into account human visual perception and cognitive aspects in the design of an effective visualization.
- *Evaluation*: common HCI tests should be made, but it is important to keep in mind that evaluating interfaces on mobile devices requires additional considerations.

Despite of some limitations, MHCI also has some advantages over normal HCI like portability, ubiquity and the ability to elicit contextual information and use it. The last one is a very important feature of mobile devices, context can be defined as any information that is used to characterize the

situation of a person, place or physical or computational object [44]. In mobile devices, context can serve as a potential trigger for information needs, as well as a factor affecting information need fulfilment [43].

When using mobile devices there are four main types of context: location, time, activity and social surroundings. For example, a user can access information based on his current geographical location, season, activity being performed and nearby people.

Context-aware mobile applications bring up two concepts that must be addressed: contextual sensing (detection of contextual information) and contextual adaptation (capability of the application to adapt its behaviour by using contextual information). These can be done by modern mobile devices thanks to features like light sensors, GPS, infrared sensor, compass, wireless networking capabilities, among others [41].

The paper [42] refers to an interesting context-aware application example. A phonebook, which contains context information, such as details on the contacts connection status, availability preferences, and location, was implemented. This provides the user with additional information when making the decision whether or not to call someone. For example, the user could see if someone on his contact list was near him and available to arrange a meeting.

2.3 Augmented Reality

Augmented Reality (AR) is a technology, which allows the user to interact with virtual images using real objects in a seamless way, unlike Virtual Reality where the user interacts with a full virtual environment. AR technology generates virtual images that will overlay physical objects in real time [3].

According to Ronald Azuma, AR can be seen as a technology which combines real with virtual in a real environment, provides the user with real time interaction, registers the virtual imagery with the real world, and applies to senses (audition, vision) [30]. In short, AR supplements reality, although it includes the idea of removing part of real environment (mediated or diminished reality) [30]. This opens new ways to explore user interaction in several areas like education, entertainment, or persuasive technology.

Commonly AR applications rely on “see-through” devices that overlay graphics and text on the user’s view of his surroundings. For example, in [47] the popular game, idSoftware’s Quake was extended to an outdoor/indoor mobile augmented reality application.

The study [31], AR books were created using ARToolkit technology where physical pages contained markers and the stories’ main characters were represented by paddles also with markers on them. This setup allows the user to see a mixture of real and virtual content in a computer display and interact with the story.

The AR books were presented to children so they could interact with them. The stories would start with text pages on the computer and in each scene interactive sessions take place encouraging the children to solve different scenarios and interact with content displayed on the book-pages and paddles. After completing these sessions the children could advance to the next scene or repeat the interactive activity. This type of augmented literacy provides children a more engaging way of reading books and facilitate the recall of the story events. Collaborative reading is also boosted as it increases chances of finding alternative ways to complete the interactive sessions.

Another example of an AR research work, “Map Torchlight”, attempts to solve the problem of *magic lens* interfaces, where users have to switch their attention between the AR device and the information in the background, by using a camera projector to augment the background [32].

2.3.1 Augmented Reality in Persuasive Technology

AR allows computer products to narrow the gap between the environment and the presentation of information concerning it. Sean White explores this ability and how to implement it on persuasive systems [33]. This paper proposes that if augmentation affects the way we perceive the environment and our world, and if we can control that augmentation, then we can affect behaviour [33]. For example, hazardous objects could be overlaid with a red aura so users would easily avoid contact with them.

Augmented Reality can be used to change the user’s perception and attitudes towards something in the environment. This is achieved by augmentation of objects or areas within our field of vision: if more information about them is conveyed, a sense of curiosity, learning and understanding is encouraged. People tend to have a different relationship with things they can name and know, and by calling their attention to something in the environment it is possible to change their attitudes or behaviour towards it.

Interaction using AR technology is also being explored in treatment of psychological disorders [34]. In this study, an AR system is used for treatment of cockroach phobia by showing virtual cockroaches overlaid on the patient’s table (figure 2.4).



Fig. 2.4 - ARcockroach

Users can also kill the several cockroaches by using two available items: a flyswatter and a cockroach killer. Both items have a marker and are used on the patient's progressive treatment. The study proved that AR exposure was effective for the treatment of phobia to small animals.

2.4 Image Processing – Object detection

In order to effectively use Augmented Reality technology, it is very important to be able to detect objects in the images captured by a recording device. The following sub-section present related work on object detection, especially vehicles.

Genetic Programing

In [35], a genetic programming based methodology to detect moving objects is presented, which does not require the implementation of existing motion detection algorithms. The evolved programs can detect genuine moving objects such as cars and boats, while ignoring background movements such as waving trees, rippling water surface and even pedestrians.

These programs provide reliable performance under different lighting conditions, either indoors or outdoors. Furthermore no pre-processing of video input is required which is usually mandatory in conventional vision-based approaches [35].

Vehicle Detection

The research work presented in [36] relies on real-time video analysis to detect and track vehicles ahead for safety, auto-driving, and target tracing. This paper describes a comprehensive approach to locate target vehicles in video under various environmental conditions. The extracted geometry features from the video are continuously projected onto a 1-D profile and are constantly tracked.

The work relies on temporal information of features and their motion behaviours for vehicle identification, which compensates for the complexity in recognizing vehicle shapes, colours, and types. The researchers probabilistically modelled the motion in the field of view according to the scene characteristic and the vehicle motion model. The hidden Markov model is used to separate target vehicles from the background and track them probabilistically. The approach presented is robust and effective in dealing with changes in environment and illumination and makes possible real-time processing for vehicle-borne cameras [36].

3D Vehicle Detection

Research work presented in [37] approaches vehicle detection by performing a sensor fusion of a laser scanner and a video sensor. This combination provides enough information to handle the problem of multiple views of a car. The laser scanner estimates the distance as well as the contour information of observed objects. The contour information can be used to identify the discrete sides of rectangular objects in the laser scanner coordinate system.

The transformation of the three-dimensional coordinates of the most visible side to the image coordinate system allows for a reconstruction of its original view. This transformation also compensates size differences in the video image, which are caused by different distances to the video sensor. Afterwards, a pattern recognition algorithm can classify the object's sides based on contour and shape information. Since the number of available object hypotheses is enormously reduced by the laser scanner, the system is applicable in real time.

In addition, video-based vehicle detection and additional laser scanner features are fused in order to create a consistent vehicle environment description [37].

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3 Design Process

This chapter describes the design process involved on the development of eVision, a iPhone application prototype which provides an environmental scanner with a game activity embedded and offers the user an alternative view of the surrounding environment in a fun and interactive way. The eVision application also introduces a virtual character, which interacts with the user helping to persuade him to have better pro-environmental behaviours and making him aware of environmental threats in his surroundings.

3.1 Description and Objectives

The solution that was used on this thesis had key objectives, which are described on the following topics:

- Inform users about their surroundings and the consequences of environmental threats in the surrounding environment;
- Encourage them to change their behaviour towards the environment;
- Offer digital rewards for completing pro-environment tasks;
- Create a bond between users and virtual characters to make them more receptive to advices and suggestions;
- Make possible to share data through social networks;
- Make all this an entertainment experience.

To better understand the intended system and how the objectives were achieved consider the following scenario example.

It is summer, the user walks towards a nearby beach and on his way he uses his smartphone to scan the surroundings. The first thing he notices is geo-referenced information displayed thanks to augmented reality text boxes. These items overlay points of interest concerning static environmental threats and provide information about them (e.g. how hazardous they are) and present information about the air quality on the user's current location.

After a few seconds, a virtual character called Snowkin appears (the application mascot) inciting the user to engage in a mini-game called "cleaning the area". This mini-game consists on "cleaning" the environment around the user, which is achieved by taking a picture of the surrounding environment which will be processed to point out dynamic threats (e.g. cars and planes). After this the user will be able to progress by rubbing his finger on the screen surface over the items detected by the scanner. Doing so the user deletes the hazardous items, replacing them by cartoonish environmental

friendly ones (e.g. cars are replaced by people riding bikes and pollution facilities are replaced by solar panels or eolic fans), and the virtual character rewards him with points and moral boosts.

After reaching a certain amount of points the game's virtual character will praise the user's virtual pro-environment behaviours, pointing out how much CO2 emissions would be avoided if his actions were real, and Snowkin will also present the user with some trivia regarding the hazardous effects of air pollution and CO2 emissions. Besides the positive feedback of the virtual character, the user will also be rewarded with in-game currency, which can be used to buy items at the in-game store (eStore). These items can be used to customize the game's mascot according to the user preferences.

At any point in time the user can also view is "All time statistics" (e.g.: time spent scanning, cars eliminated, etc.) or share the same data through the social network Facebook.

Even though the user is not actually doing anything "real", he is being induced to adopt better environmental behaviours by being informed about the real impact of the pro-environmental actions. He is also stimulated to improve his performance by the possibility of sharing his results and customize the virtual character, making him want to continue playing.

The scenario presented describes the basic principle behind the application developed for this thesis, having this into account it is possible to divide it in seven major points:

1. General information about environmental offensive agents through Augmented Reality

Information will be displayed on the mobile device, making the user aware of surrounding environmental threats. The information will be given through text boxes, which will overlay the point of interest (environmental threats) location. Points of interest's location can be given by geographical coordinates data.

These text boxes will contain data specifying the name of the threat and information about the number of emissions produced buy it. The later provides another level of environmental consciousness to the user making her wonder about the sustainability problems of our planet.

2. Landscape alteration through Augmented Reality

The landscape captured by the mobile device's camera suffers virtual alterations as a means of user feedback thanks to Augmented Reality techniques. Every time the user eliminates an environmental threat, by rubbing her finger back and forth on the screen, she receives feedback by overlaying cleaned area with a cartoonish version of a pro-environmental way to avoid the harmful effects of the threat. This type of feedback keeps the user interested on the activity, while being pleased with the alterations he is performing on his surroundings.

3. Give user positive reinforcement

According to the reinforcement theory, behaviour is more likely to be repeated if reinforced [48]. In this thesis we applied this theory by praising positive actions and rewarding the user with things she would appreciate. Praising is done by the game's virtual character with motivating dialogues every time the user cleans a threat. This and the on-screen score gauge will encourage the user to complete her task without giving up.

The reward system is a bit more complex. When the user finishes cleaning an area she will be awarded with a final score and in-game currency (illustrated as green leaves) based on that action. Afterwards, she can spend the earned green leaves in the in-game store, buying items that can be used to customize the virtual character, turning it into an avatar that represents all virtual pro-environmental actions performed by the user over time.

By providing this type of positive reinforcements the user is persuaded to continue playing, proud of what she has achieved. Moreover, this strategy makes it possible to keep providing her with information about environmental issues, concerns and ways to fix them.

4. Provide information about the consequences and gains generated by the user actions

One of the most important aspects to persuade the users to adopt better pro-environmental behaviours is to show them the positive consequences of their actions. Users will be presented with this kind of information after they finish cleaning an area, thus becoming aware of the possible positive behavioural changes towards the environment.

5. User and Virtual Character bond

The creation of a virtual character that interacts with the user helps to persuade him to adopt certain types of behaviour, and with right timed interventions the character can actually encourage the user to continue playing. The longer the user keeps playing the more information about environmental issues can be conveyed to him, improving the results of the persuasive process.

Besides what was previously mentioned, the fact that the user puts some amount of work and dedication building the virtual character's appearance (e.g. buying clothes to dress it) creates a "bond" between them, making the user more likely to follow the character's advices and recommendations about the environment thus being persuaded by the application.

6. *Digital ways of advertising*

Social networks took the Internet by storm in the recent years, placing themselves as one of the fastest growing phenomena on the web. With social networks came the ability to reach a mass number of people with relative ease and persuade them to change their attitudes and behaviours.

Founder of Stanford Persuasive Technology Lab, B.J. Fogg, calls this type of persuasion MIP (Mass Interpersonal Persuasion) and ranks it as the most significant advance in persuasion since the radio invention [7]. This was possible thanks to the large success of the social network Facebook and the release of Facebook Platform (an API and related tools), which enabled the creation of third-party applications that could reach and persuade, in a proper way, millions of people connected through the social network.

On this thesis' application it will be possible for users to share their eVision's statistics on Facebook through Wall Posts. This process enables a very powerful type of advertising and persuasion, because people tend to trust or show interest in content generated by those they have accepted as friends [8]. Therefore, taking into account that persuasion sometimes occurs due to imitation of others [9], more people can be expected to fulfil the defined objectives.

7. *Indirect competitiveness and entertainment*

Every action of the user on the application is measured and ranked through scores, statistical data and the items acquired on the in-game store. The ability to share this with friends, on social networks or simpler ways, gives the application an indirect competitiveness aspect that will motivate users to compete between them in search for a better score or simply the best looking virtual character.

To make possible the implementation of an application that encapsulates all the described design decisions and is able to reach the proposed solution objectives, it was necessary to have an hardware capable of reading touch-based gestures, camera, compass, GPS and Wi-Fi incorporated. Having this in mind the expected decisions would be most of Android smartphones and Apple's iPhone® and iPad® line. The device chosen for implementation was the iPhone® due to the fact that we already have that kind of devices at our disposal and the ability to port the developed application for iPad® in the future. For the device decision was also considered the iPhone hardware, which is similar in most models unlike Android smartphones.

The language used to develop the application was Objective-C in conjunction with the OpenCV library. The reason behind the use of OpenCV lies on the fact that an image processing framework is required for the detection of the environmental threats and the augmented reality implementation.

The solution implemented for vehicle detection was done by limiting the number of possible vehicle types that can be detected - a set of specific features was predefined in the application (car plate). Unfortunately this also limited the possible viewing angles to identify a vehicle, which was considered to be acceptable giving the focus of this thesis and the ability to conduct the evaluation tests on a controlled environment.

The vehicle detection process was decided based on performance tests and on the complexity of the implementation, having been tested other methods.

Airplane detection was simpler thanks to the sky's colour uniformity, generally blue, making able to detect objects (airplanes) based on background subtraction technique or contours detection. This implied some limitations, like birds sometimes being detected as airplanes or clouded skies which will difficult background subtraction and contour detection. But we believed those limitations would not cripple the user experience.

The image processing features presented on the solution developed will be explained with more detailed in chapter 5 (Second Prototype).

Due to the functionalities previously described, the system was entitled eVision, an application that would give the user an alternative ecological view of the world around him.

In terms of the virtual character implementation, several studies have demonstrated so far that using a virtual character based on an animal or "thing", rather than human-like, is more prompt to success, because users prefer less realistic agents in learning environments [10]. Moreover, if the characters' verbal response is not satisfying, users will forgive them, because realistically animals do not verbally communicate [11].

The use of animals or "things" prevents us from having to visualize properties of a particular culture (since the virtual character should be culturally neutral) and animals that are perceived as cute may facilitate the creation of affective relationships. Despite of being a human like avatar or an animal it should be expressive, and able to communicate (verbally or not) with the user in a convincing way.

For example, a virtual character based on a fish would have difficulties to shrug to express doubt, for instance. A high degree of expressiveness facilitates not only the comprehensibility but also promotes empathy - the user creates an affective bond with the character.



Fig. 3.1 - Snowkin (happy expression)

All the previous ideas were taken into account when designing the final aspect of the game's character. The final design was based on a cross between a polar bear, one of the most negatively affected species by climate change, and a snowman with his name being Snowkin. The virtual character name was created based on its snow-white colour (Snow) and the intention to make a bond or relationship between it and the user (kin). Other names were considered during the first prototype process as will be explained on chapter 4.

After defining the base concepts and objectives it was envisioned that the system created would have mainly two persuasive roles: Tool and Social Actor. eVision presents users with a form of gathering environmental hazardous information about their surroundings and a game activity which gives them the ability to see the cause and effect of the elimination of those environmental threats. With the implementation of a virtual character like Snowkin it was possible to approach the persuasion theme from another, more complete, angle.

Next are presented how the concepts of the functional triad were applied on designing eVision mobile application:

As Tool

- *Tailoring*: information can be more persuasive if it is tailored according to the individual's interests and personality, eVision approached this principle by letting the users customize the appearance of Snowkin. By having a virtual character, whose appearance was tailor made by and for the user, gave eVision the possibility of better persuade the user through Snowkin speech and reactions. Other application of the tailor principle was the fact that Snowkin always addresses the user by his name, giving him a sense of uniqueness.
- *Suggestion*: intervenes at the right time providing suggestions to encourage a certain behaviour were a big focus of eVision's design. The suggestion principle application can be divided into two different moments: before and while the user is participating in the game activity and after the activity is completed. In the first moment, Snowkin suggest the user to engage in the

cleaning of the environmental threats while keeping him motivated to keep going with motivational speech. The second moment is the most suitable to present environmental information to the users, because it has all his focus and attention, while during the other phases of the activity the user is more concerned in searching threats and finishing the current level. When a user finishes an activity he is presented with information regarding his performance and environmental gains related to it, as well as information about hazard effects of the threats in the environment.

- *Self-monitoring*: monitoring the users actions helps to persuade them to change their attitudes or behaviours towards the environment, helping them to achieve predetermined goals or outcomes. This is implemented in the form of user statistics, which users can consult, and share throughout the social network Facebook.
- *Conditioning*: positive reinforcement can be crucial to shape and change complex behaviours or attitude. In eVision this principle is applied by rewarding users for finishing a game-activity level with in-game currency based on their performance, which can be used to purchase items to customize Snowkin. This allows to keep the user motivated to repeat the task in the future, creating a routine that allows more chances to apply persuasion for better environmental behaviours or attitudes.

Media

- *Cause-and-effect scenarios*: this principle allows the users to see the consequences of their input actions allowing to persuade them in subtle ways. In eVision this was achieved by letting the users know how much CO2 emissions would be eliminated by their actions and making them aware of the harmful effects that things on their everyday life have on the environment. This can subtly persuade the users to adopt behaviours, which allow saving on CO2 emissions and consequently helping the environment.

Actors

- *Physical*: visual appeal can be a powerful way to apply persuasion and eVision applied this principle in two different sections. First it was given a special attention and care to the visual elements of the interface (colours, shapes, images, etc.), second it was conveyed a social presence through the virtual character which may enhanced the persuasive results.
- *Psychological*: this type of cues is very important and eVision integrates them through Snowkin, making the users perceive emotions and a personality from it. This ultimately provides the ability to make users sympathize with the application, consequently improving the persuasive effect pretended.

- *Language*: eVision also uses language cues to convey a social presence, leading users to be more open to persuasion. The application uses a highly positive and motivational speech, especially through Snowkin, stimulating the users to not give up and continue to rehearse pro-environmental behaviours through eVision. Regarding the visual language, Snowkin is also highly expressive which make users easily sympathize with it and continue to pay attention to its speech.
- *Social Roles*: the last social cue used on eVision is also applied through the application virtual character. This is achieved by conferring Snowkin a role of authority or someone with a higher knowledge. This lead users to be receptive to persuasion from the Snowkin, because they expect suggestions and helpful information from those kinds of figures.

Taking into account the aforementioned concepts, principles and goals it was concluded that the mobile application should have seven different sections or interfaces:

- I. Main Menu, which is used mainly to navigate between eVision's options or features.
- II. Scanner, which is responsible for the environmental scanner and offering the game activity to the user, as well as providing a place to Snowkin interact with him.
- III. Snowkin, that provides a place for the user freely customize the virtual character with the items gathered.
- IV. eShop, section with items available to be bought with currency won playing the game activity which can be used to customize Snowkin.
- V. Statistics, a section responsible to keep track of the user progress and general statistics.
- VI. Facebook, which allows users to login on Facebook, post their statistics on the Wall and like the DEAP Project Facebook page.
- VII. Help, lastly was needed a section to offer a kind of tutorial to help users understand all the functionalities of the mobile application.

3.2 Design Methodology

In order to apply all design decisions and achieve the objectives proposed, was followed an iterative design. A deliberated design process that overcomes the inherent problems of requirement specification by cycling through several designs [53]. This allowed to improved the product with each cycle pass and was achieved with the use of prototypes. The iterative cycle can be seen as designing, prototyping, evaluating and improving the final product where users play an important role.

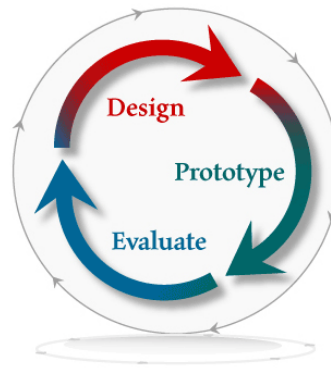


Fig. 3.2 – Iterative Design

Using this type of design process allowed to improve the quality and functionality of the final user interfaces, inconsistencies were easier detected and dealt with. It makes easier to focus on critical issues and allows the evolution of the product from a low cost prototype, which allows to assert problem solutions, to a full fledged prototype with all features and functionalities working as foreseen.

The throw-away approach (knowledge gained from the prototype is used in final design but the prototype is discarded [53]) was adopted for eVision that went through the following design phases:

- *User and Task Analysis*: this phase helped to gather information about the characteristics of the target population and to analyse the tasks and their features that were planned for the persuasive technology.
- *Design, development and evaluation of the first prototype*: creation of a paper prototype based on the task analysis, which was used to conduct user tests and an informal interview to assert future improvements and problem detection.
- *Improvement of the original design*: based on the user tests the final design was improved and the development of the computational prototype was planned.
- *Design, development and evaluation of the second prototype*: the final computational prototype was implemented and subjected to the evaluation process (usability and impact tests). This prototype had to be fully functional to make possible the study the success of the intended persuasion.

3.3 User and Task Analysis

This section focuses on helping the eVision's design by identify, analyse and understand the users, the tasks performed by them and the environment where they do it. This collection of data allowed to obtain a deeper knowledge about our target audience making possible to identify the tasks, which the system must perform, as well as their hierarchy, goal, conditions, exceptions and importance.

3.3.1 User Analysis

The target audience of the implemented solution is mostly young adults and teenagers, due to three main reasons:

- They represent a great portion of mobile device market, [49]
- The majority of Facebook users are within this audience, [50]
- It is easier to change behaviours of the mentioned audience through the proposed methods than older people, because they tend to be more resistant to change. [51]
- It is believed that this audience is more open to gadget entertainment (e.g. games).

Most design choices have the target audience in mind, but that does not mean that other people cannot enjoy and benefit from it. People without a Facebook account could use the application without using the sharing component, young kids can always use it under adult supervision to better understand the aspects behind it and elderly people can explore its particularities too.

3.3.2 Task Analysis

The following tasks are the main ones allowed by the eVision application, there are more tasks present in the application but this chapter describes the high-level ones.

Task 1: Read the instructions

Goals	Allow the user to consult the Help menu in order to better understand the goal and structure of the application. This can also be seen as a Tutorial for how to interact with the mobile application.
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Pre-conditions

Subtasks

Exceptions

Task 2: Configure Facebook Access

Goals	Allow the users to login with their Facebook credentials, so that they can be identified by name within the application, as well as have access to other social features.
Pre-conditions	Pre-condition 1: The user must have a valid Facebook account. Pre-condition 2: Access to the internet must be available, either by Wi-Fi or a 3G account.
Subtasks	The user is prompt to insert her or his Facebook credentials.
Exceptions	The authentication may fail because the account provided by the user is invalid or the credentials could not be correctly verified. Complications can also rise if the internet connection is not stable enough or is absent.

Task 3: Use the Scanner

Goals	Allow the user to use the Scanner feature in order to consult the location's air quality and scan the surroundings for environmental threats.
Pre-conditions	Pre-condition 1: The GPS functionality is enabled on the device. Pre-condition 2: The user's location has an air station in a radius of five kilometres or less. Pre-condition 3: The user must be near a environmental threat (e.g. industrial factory) and facing its direction with the mobile phone.
Subtasks	Start the game activity, Detect and Clean an environmental threat, Consult all information when finishing an activity, Continue to the next level of the game activity
Exceptions	The user may not consult his location's air quality because there is not an air station in a radius of five kilometres. It is also possible to not find any static environmental threat because the GPS has no signal or there is not one near the user's location.

Task 3.1: Start the game activity

Goals	Allow the user to accept Snowkin invitation to start the application's cleaning activity.
Pre-conditions	Pre-condition 1: Snowkin appears on the device screen. Pre-condition 2: The user accepts Snowkin's invitation to start the cleaning activity.
Subtasks	The user must tap the device screen in the Scanner mode to prompt Snowkin's dialogue and accept its invitation.
Exceptions	The activity is not started if the user does not accept Snowkin's invitation to take part on the cleaning activity.

Task 3.2: Detect and Clean an environmental threat

Goals	Allow the user to detect and clean an environmental threat when participating in the game activity, in order to gain points and progress in it.
Pre-conditions	Pre-condition 1: The game activity is taking place. Pre-condition 2: The user captures an environmental threat (e.g. car, airplane, factory) with the device's camera. Pre-condition 3: The environmental threat is properly detected and highlighted by the system.
Subtasks	The user captures an image of an environmental threat near him through the mobile device, by tapping the "Capture Image" button. After the threat has been detected and highlighted by the system, the user rubs his finger on the threat's screen location to clean it.
Exceptions	An environmental threat cannot be detected if there is not one presented on the image captured by the device. Due the characteristics of image processing the system may also fail to proper detect an environmental threat on the device's video feed. The threat is not cleaned if the user does not rub his finger enough times on its screen location.

Task 3.3: Consult all information when finishing an activity

Goals Allow the user to consult information related with the environment and regarding his activity performance, as well as the benefits of his actions towards the environment.

Pre-conditions Pre-condition 1: The current activity level is cleared or the user quits the activity.

Subtasks

Exceptions The information is not presented if the user does not end the activity, either by finishing the level or quitting it. Information regarding user's performance is not showed if the user does not do anything relevant (e.g. does not clean any threat).

Task 3.5: Continue to the next level of the game activity

Goals Allow the user to continue the game activity by resetting the score gauge and increasing the points needed to fill it again.

Pre-conditions Pre-condition 1: The current activity level is cleared.

Subtasks Select to continue to the next level.

Exceptions The next level option is not presented if the user quits the current activity level without completing it.

Task 4: Consult the eShop

Goals Allow the user to check all items intended for Snowkin customization available for purchase.

Pre-conditions

Subtasks Buy a Snowkin Item from the shop

Exceptions

Task 4.1: Buy a Snowkin Item from the shop

Goals	Allow the user to buy a desired item with in-game currency to customize the Snowkin's appearance.
Pre-conditions	Pre-condition 1: The user has the needed amount of in-game currency (green leaves) available. Pre-condition 2: The user did not previously bought the item selected. Pre-condition 3: The user confirms the purchase.
Subtasks	Select the pretended item and after seeing its preview on Snowkin confirm his purchase, by answering yes on the prompted confirmation dialogue.
Exceptions	The user cannot buy items on the eVision's store if he has not the amount needed of green leaves to match the item's price or if he had already purchased the item selected. The purchase will not be completed if the user answers "no" in the purchase confirmation dialogue.

Task 5: Customize Snowkin

Goals	Allow the user to customize Snowkin with items purchased on the eShop.
Pre-conditions	Pre-condition 1: The user has already bought at least one item from eShop.
Subtasks	Scroll through the available items and select the one to equip in the elected Snowkin body slot (head, torso, legs, feet and hands).
Exceptions	Snowkin customization is not possible if no item has yet been purchased from the mobile application store.

Task 6: Consult the user statistics

Goals	Allow the user to inspect the statistics gathered throughout the life of the mobile application.
Pre-conditions	
Subtasks	
Exceptions	

Task 7: Share user statistics through the Facebook network

Goals Allow the user to share his eVision's statistics through Facebook's profile Wall.

Pre-conditions Pre-condition 1: The Facebook credentials are authenticated.

Subtasks

Exceptions Statistics will not be published if the user is not authenticated with Facebook.

Task 8: Like the DEAP Project Facebook Page

Goals Allow the user to like the DEAP Project Facebook page.

Pre-conditions Pre-condition 1: The Facebook credentials are authenticated.

Subtasks

Exceptions The like option will not be available if the user is not authenticated with Facebook.

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4 First Prototype

Prototyping is one of the most important parts of the iterative design and the initial prototype is crucial for the development of any interactive system. A paper prototype can be very useful thanks to the low costs, ease in modifying and promotes an user-centered design, allowing users to better understand the system presented and making easier to identify future issues with the model currently being developed.

Even though the early prototypes are low fidelity they can include most of the functionalities that will be present in the computational prototype, as more functionalities are included more easily is to make early design decisions, which potentially could cost time and money if they were made on a later design cycle. While prototyping helps, it is important to notice that no initial design decision should be so great that when a problem with it is discovered the designer is forced to drastically change the application's envisioned goal or purpose. It is also important to try to solve the problems found on the system design and not its symptoms [53].

4.1 Paper Prototype Description

In this sub-section it is presented the paper prototype used to conduct the first design evaluation tests. Figures 4.1 to 4.8 represent the main areas of the envisioned application, created based on the user task and analysis and system's goals.

Note: The images are photos from the original paper prototype so it is possible that the image quality is not 100% faithful to the live setting, nevertheless was decided to show this images to give a better idea of the first prototype evaluation process.

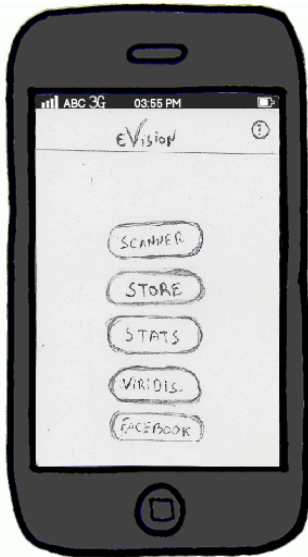


Fig. 4.1 – Main Menu

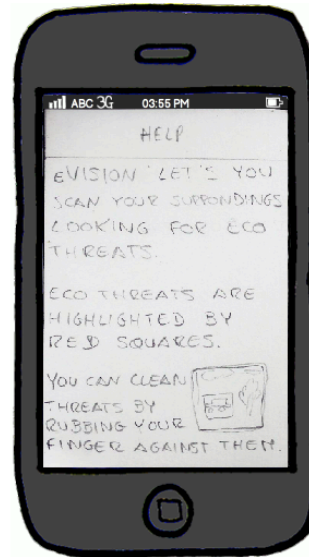


Fig. 4.2 – Help Menu

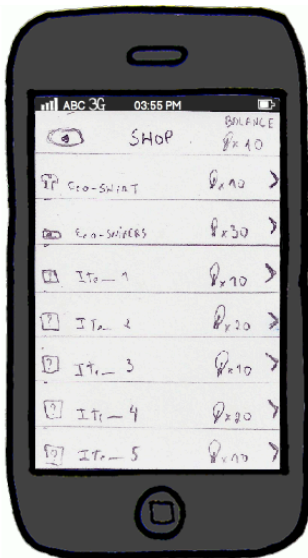


Fig. 4.3 - eShop



Fig. 4.4 – Viridis (future Snowkin)



Fig. 4.5 – Scanner Mode

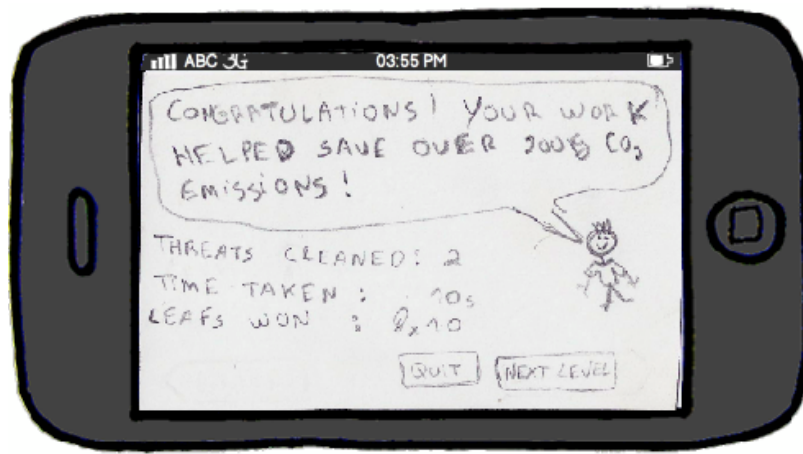


Fig. 4.6 – Activity End

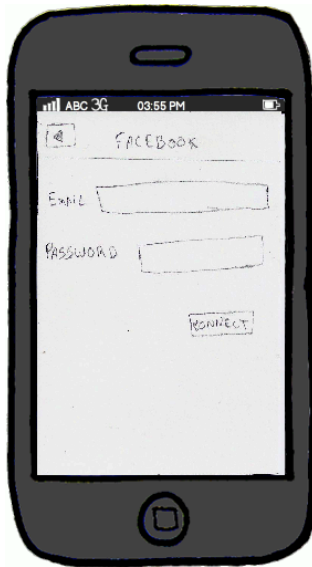


Fig. 4.7 – Facebook (User logged out)

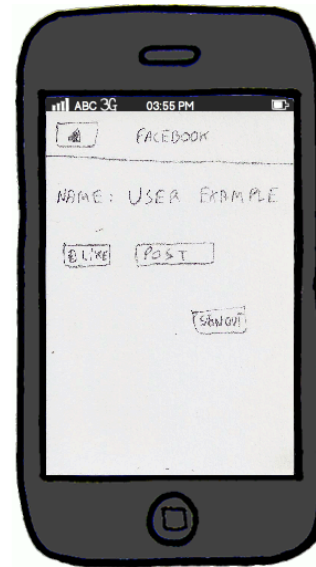


Fig. 4.8 – Facebook (User logged in)

As stated on chapter 3.2 a throw-away approach was adopted for this prototype, the knowledge gained for building and testing it was used on the final prototype development but, in the end, this paper prototype was thrown away.

Although disposable, this prototype helped greatly the design of the mobile application eVision as will be shown on section 4.3 (Discussion and Results).

4.2 Evaluation Methodology

The developed paper prototype was an interactive mock-up where participants performed scenarios. Initially it was avoided to give too many instructions to assert if the interface disposition was intuitive, if the user struggled to complete a certain task then he would receive extra indications.

Participants used their fingers to interact with several hand-drawn interface elements and were always encouraged to think aloud, enabling a better judgment regarding the prototype's design problems.

The evaluation tests were conducted in three phases: the first was executed with a paper prototype freshly finished without user feedback, the second was made with an improved paper prototype based on the user feedback and the last one was conducted only to make sure everything was fixed. At the end of every test, users were informally enquired about their experience and requested to give feedback about future improvements.

The first phase of the paper prototype evaluation was conducted in the Faculdade de Ciências e Tecnologia – Universidade Nova de Lisboa, with eight participants with ages between 23 and 46 years old (six male, two female). In this phase, all participants had experience using smartphones in general, but only three participants had previously used iPhone. The second phase had also 8 participants this time with ages between 13 and 56 years old (five male and three female), most without any experience with iPhone or even smartphones in general. Finally the last phase had only two participants one male with 17 years and highly experienced with iPhone, and one female with 51 years without any type of experience using smartphones. The graph represented on figure 4.9 represents the age distribution of all evaluation tests' phases. Furthermore, all three phases had different users between each other.

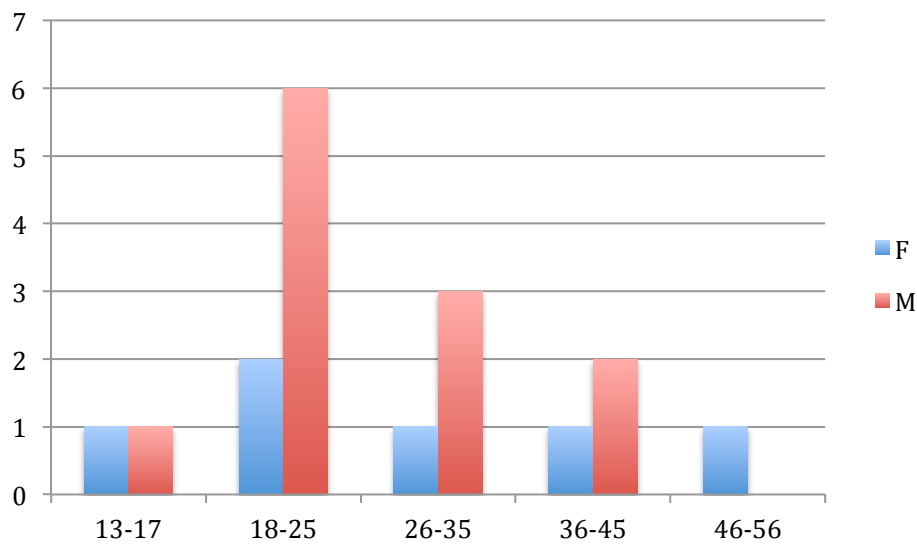


Fig. 4.9 – Participants age group

Before each test, an explanation of what was eVision and its purpose was give to participants, along with some instructions to carry out the proposed scenarios. Every test was merely conducted with one user at a time to improve his focus on the prototype and increase chances of meaningful

feedback. Given the context of the prototype the following introduction was given to all users, in all phases:

“Imagine that you are walking alone on your way home or to school and you remember that your iPhone has the ability to scan your surroundings, searching for environmental threats. You pick it up out of curiosity and start scanning. Suddenly your iPhone starts talking to you through a virtual character. You have then the ability to engage on a game activity and start cleaning all the threats you had previously found and more! To accomplish that you rub your finger on the threat’s location and, even before you know it, you had helped on the sustainability of our planet. After cleaning all those threats you are informed about our planet’s sustainability problems and how your actions affects our planet. You are also rewarded for things like number of threats cleaned, hazard level or even your speed cleaning them, and you can use those rewards to improve your virtual character appearance! And after all this thrilling experience, you share everything with your friends across the Internet!”

When the introduction was over and the participants fully understood the purpose of the mobile application, they were presented with the paper made iPhone. Four scenarios were presented to each user with the description of each task that should be accomplished by them in the test process. Users only carry out one scenario at a time, having access to the next when they completed the previous one.

The four scenarios presented were the same in all phases with the exception of the virtual character’s name, which was Viridis in the first phase and Snowkin in the others. The scenarios presented to all participants are the following:

Scenario#1: *“Start eVision and read the instructions presented on the Help Menu. After you have completed your reading go to Facebook Menu and login with you credentials.”*

Scenario#2: *“Use eVision’s Scanner mode and search for environmental threats. When the virtual character Viridis appears, accept his invitation and play the proposed game by cleaning the detected environmental threats, continue until you finished the level. After completing the level, read what Snowkin is telling you and check your performance and reward.”*

Scenario#3: *“Use the points gained by completing the previous scenario and buy an item for Viridis in the eShop. After completing the desired purchase head to the Viridis customization menu and use the freshly bought item to customize your virtual character.”*

Scenario#4: *“Share the results of all previous scenarios with your Facebook friends and Like the DEAP Project Facebook page.”*

After the completion of each test a small informal discussion with the participant took place, mostly to gather feedback about her or his experience with eVision’s prototype. The user could also make suggestions for future improvements and was asked to give his opinion regarding the application and virtual character.

4.3 Discussion and Results

This section presents the discussion of results gathered after the evaluation tests regarding the first prototype. Problems found in each iteration of the eVision first prototype will also be discussed, as well as their solution and consequence prototype modifications.

Paper Prototype – First Phase

As previously stated the first phase of the user tests was conducted with a paper prototype as first was envisioned, without any kind of user feedback. This phase revealed some problems with the designed interface, but nothing that obliged a complete overhaul of what was initially planned. The most serious problem found on this phase was more related to the game activity and environmental threats detection than with the interface elements. All feedback and idealized solutions are summarized on table 2:

Interface	Problem	Solution
Main Menu	Button disposition was not intuitive regarding their importance.	Reorganize the Main menu buttons according to their use rate or importance. Store and Viridis should be next to each other and Facebook should be the “last”.
Facebook	Facebook interface was generally viewed as bland and without any kind of meaningful feedback about the user.	Redesign the Facebook menu. A user portrait should be present to confer a sense of personality. Viridis should be present holding the user portrait, increasing the persuasive physical role of the application.

All Virtual Character's Appearances	User found the first though name for the virtual character (Viridis – Latin word for green) uninteresting and without the “catchiness” pretended.	Rename the virtual character to something more meaningful and catchy. The name Snowkin was conceived. The character would be all white, resembling snow, and the name should suggest a really close relationship with the user, emphasising its social role.
Scanner	Users found the absent of a way to pause the game activity to be pressuring making them uncomfortable.	Replace the exit button with a Pause button that paused the game and allowed the user to quit.
Scanner	Many questions were raised regarding the viability of cleaning threats in a live setting where they (and even the iPhone) may be moving.	Change the way environmental threats were found on the game activity. Introduce the ability to take snapshots that would capture the user's surroundings, serving as an interface to clean threats.
Activity End	Score was very undetailed.	Introduce on the scoreboard the type of threats cleaned instead of their total number.

Table 4.1 – Problems found on the paper prototype (First Phase)

The first phase of tests went pretty well, considering that the presented paper prototype was the first one made, without any type of feedback from an outside user. Notwithstanding, the prototype was not perfect, far from it, but helped to change some crucial aspects that would bring severe problems to the computational prototype and probably affect the intended persuasive effect success.

The most notable problem occurred in the Scanner mode of the application and it concerned the act of cleaning threats. Some users expressed they fear regarding the viability of cleaning the threats on a live setting situation. Consider the following situation: *The user was walking home and aims the device high to capture a moving airplane. While he is walking and the airplane is moving he have to rub is finger on the iPhone screen while still aiming to the sky.* As can be seen the task would be complex and frustrating from the user standpoint and, being the game activity a core feature to achieve the persuasion effect desired on eVision, a solution had to be found. Our approach to handle this issue was to change the dynamic threat detection from the real time video to a snapshot, this way the user could detect the environmental threats presented on his surroundings in a more relax way without

having to do complex and simultaneous actions. Other problem detected on the Scanner mode was the lack of a pause option when the user was engaged on the game activity.

One minor problem found was the button disposition for the main menu, which was changed to the order represented on figure 4.10. The virtual character name also raised some concerns, because some users did not find the name appealing and meaningful. After the tests were done the name was rethought and Snowkin replaced Viridis as the eVision's virtual character name. As explained on chapter 3.1 the name was conceived based on the snow-white colour body design and the intention to make notice of the bond or relationship between the virtual character and the user. All menus containing Snowkin were properly updated like exemplified on figure 4.11.

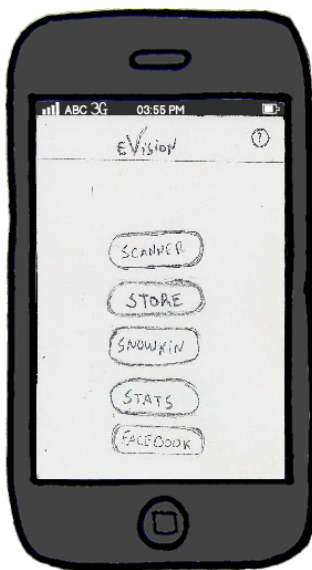


Fig. 4.10 – New Main Menu



Fig. 4.11 – Virtual Character's new name

The last two issues were discovered on the Facebook menu and the Activity end screen. The first was more important and arose due to users pointing out that the Facebook section was too bland or without any real meaningful data about the logged in user. To solve this a portrait of the user being held by Snowkin was created on the menu, taking the opportunity to increase the social actor persuasive role of the application (figure 4.12). The second issue appeared due to the fact that Activity's end screen had not very detailed information about threats cleaned by the user. To solve this issue a more detailed scoreboard was created separating the threads cleaned by type.

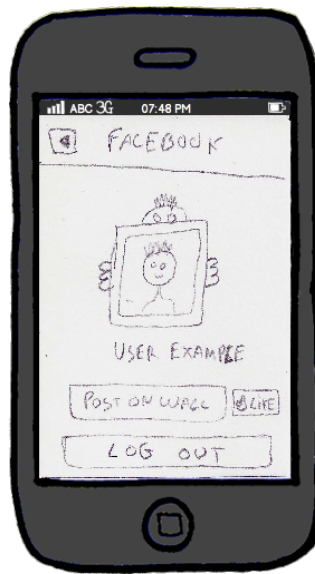


Fig. 4.12 – New Facebook Menu

Regarding the informal questions asked in the end of each test, most feedback was positive and generally the participants felt that eVision was an interesting and innovative application. The interface did not present major flaws requiring an overhaul and most of the users' experiences went smooth.

Paper Prototype - Second Phase

After making the modifications aforesaid, the second version of the paper prototype was tested with a new group of participants. Even with the modifications some problems were expected to arise but surprisingly only one problem was detected during the evaluation tests. Having in mind that most of the participants in this phase had little experience using an iPhone makes the results very positive. Still one problem was found and needed to be addressed as presented on the table 3:

Interface	Problem	Solution
Snowkin Customization Menu	Customizing Snowkin was not an intuitive task and it was not clear that you could only have one item per slot (head, torso, legs, feet, hands)	Change Snowkin item bar to a more intuitive form. Use an interface element similar to a slot machine.

Table 4.2 – Problems found on the paper prototype (Second Phase)

The second phase of evaluation tests went very good, almost without problems or issues identified by participants. The only issue detected was related to the interface used to customize Snowkin (figure 4.11). Users found that the task was not intuitive and they also complained about not being clear that they could only have one item per slot. The best solution found for this problem was to transform the customization interface into a kind of slot machine element (figure 4.13). This allowed configuring each slot independently, making clear that only one item is permitted per slot, and turning the customizing activity into something more easy and intuitive.



Fig. 4.13 – New Snowkin Customization Menu

When the tests were over some informal questions were made to participants to gather feedback about the paper prototype, generally the feedback was very positive with most participants eager to test the future final version.

Paper Prototype – Third Phase

Unlike the first and second phase, the third phase of evaluation tests was a small one conducted only to assess if all changes were correctly implemented. As expected everything went well and no other problems or issues were discovered indicating that the prototype structure was ready to be the base of the computational prototype. The prototype was considered finished and discarded, using the knowledge gained with it to develop the second and final prototype.

5 Second Prototype

After gathering information and analysing the results of the first prototype tests, the implementation of a second prototype took place. While the first prototype was a paper one, with sketches and focused on the general design of the application, the second is a fully computational one which represents the final version of eVision, focusing on user's interaction and experiences, and the one used to test the persuasive effect of the concepts and ideas developed.

As stated on the Chapter 3, the second prototype was developed for iPhone 4 using iOS 5.1. All the implementation code was written using Apple's Xcode IDE (Integrated Development Environment) in Objective-C language. The eVision's interface elements were made on the Xcode's Interface Builder, having some exceptions been generated through specific code. The image processing module was developed using the OpenCV library compiled for iOS 5.1, using C++ language to write the module's code which was responsible to dynamically detect environmental threats presented on snapshots taken. For the Facebook integration was used the proper Facebook mobile API design for iOS with minor refinements.

5.1 Design

The second prototype was designed according to the evaluation results from the first prototype, having always in mind the persuasive technology concepts needed to confer the computational prototype the persuasive effect pretended for this project. In chapter 3.1 were presented seven main design points, which compose the initial plan for eVision, but as expected after the first prototype evaluation some additional design choices were made. Most of the new design decisions are complements of the previous ones, establishing exactly how some choices would be implemented to improve eVision's main goal: change users' behaviours and attitudes towards the environment.

Following are the complementary design decisions:

- *Information regarding threats and air quality*: information about threat's CO₂ emissions was gathered through websites expert on the theme [54], while information regarding air quality for every location support by eVision was taken from Portuguese Environment Agency [55]. The relevancy given to CO₂ emissions was due to the fact that it is a term the target audience is familiar with, which makes it easier for the users to assert the impact of their actions if they were real. The environmental threats were also getting a distance threshold, meaning that the user would only get information about the ones near him to save screen space and avoid overlapping.

- *Augmented Reality Overlays*: the overlays designed to replace the cleaned environmental threats on the screen were based on the type of threat they were overlaying.
- *Score and level system*: the score and level system are deeply related with each other, because the ability to finish a level is based on the score achieved by the user at the current moment. When the user get to a certain point threshold (represented by a gauge) the level is finished and the next is made available. Every time the user advances to the next level, the point threshold required to finish it is increased. The points earned for cleaning a detected environmental threat is based on its type and CO2 emissions level, being the cars the less valuable (1 point), followed by airplanes (2 points) and the factories the more valuable threats (3 points). The level score in conjunction with the time spent by the user on the level is used to gauge the performance. Based on that a certain number of leaves (in-game currency) are given to the user, calculated by multiplying the points gained for cleaning threats by the difference between sixty seconds and the time spent cleaning, divided by ten:

$$\text{leaves} = \text{points} * ((60 - \text{time}) / 10)$$

It is important to take note that if time spent on the level is superior to sixty seconds no time bonus points will be factored in the final score, turning the points gained for cleaning the final score. Penalties were also set aside, because it did not feat the desired effect of the application.

- *Snowkin items*: the items available to customize Snowkin were divided into five types based on the slot they occupy in the virtual character's body: head, torso, legs, feet and hands. To streamline the customization it was decided to let only one item be equipped per slot and balance out the number of items per type available. The price of items was also decided having their type and characteristics as a factor, so the more expensive items are the "special" designed ones with a high visual impact (e.g. cleaning broom) and the more cheap ones are the common designed ones with less visual impact (e.g. snowman buttons). In the end there were five price tiers: 10 leaves items (snowman buttons and gloves), 20 leaves items (T-shirts and scarfs), 30 leaves (hats, caps, jeans and shoes), 40 leaves (ear cold protectors) and 50 leaves (broom and sky stick).
- *Facebook connection*: the use of a social network was crucial to reach a massive number of people and having this in mind Facebook was chosen. The connection to the Facebook network was decided to be through the mobile Facebook API, but the authentication was designed to be done only once to reduce the user input needed. It was designed an interface specially for authentication and, seeing that this part of eVision is extremely personal, the presence of Snowkin was intended to be felt in it. This was achieved by making Snowkin hold the user profile picture. The message produced for Wall posting was also tailored for the user based on his name and statistics: "**Name** has eliminated **number** cars, **number**

airplanes and **number** pollutant factories. **He/She** has earned **number** green leaves to spend customizing Snowkin. All this in **time played** of fun. And you? It's time to get another vision of the world". The message created also had a link to DEAP Project Facebook page.

- *Graphic Design*: as already stated visual appeal plays an important role in applying persuasion, so eVision's visual design was thought having a cheerful tone in mind. Menus and other interfaces were colourful and with enough information presented, Snowkin is presented in every way possible and the visual design is constant throughout the entire mobile application.

5.1.1 Dynamic threat detection

Having eVision's functionality in mind, it was also required to infer the best method to dynamically detect environmental threats for eVision's game activity. In conjunction with the OpenCV library, one airplane detection method was designed and for car detection tests were conducted using two different methods.

It is important to note that the image processing was not the main focus of this thesis. Consequently, the methods developed were not perfect. In the future the methods and algorithms used can be enhanced and optimized.

For airplane detection a method was used based on contour detection and analysis. This was possible having the context of this thesis in mind, being eVision a prototype was assured that its test was conducted in a controlled environment (always on a clean sky). Limiting the sky appearance we could work based on its colour uniformity and use successfully airplane detection based on contours.



Fig. 5.1 – Airplane Contours detection

After getting all airplane's contours (figure 5.1) eVision's should draw a bounding box highlighting the environmental threat, with this intuit the internal contours were discarded and external contours bounding boxes were calculated (figure 5.2).



Fig. 5.2 – External Contours Bounding Boxes

The only step left was to create a main bounding box that contained the complete airplane's area. This was achieved by calculating the vertical and horizontal limits (min and max) of the bounding boxes set.



Fig. 5.3 – Airplane Detection (1)



Fig. 5.4 – Airplane Detection (2)



Fig. 5.5 – Airplane Detection (3)

The final results of the designed method had great results, sometimes even detecting airplanes over a non-uniform sky (e.g. cloudy backgrounds) like in figure 5.4 and figure 5.5. In terms of processing

speed the method prove to be also quick on iPhone hardware. The processed images were also downscaled from 2592 x 1936 (iPhone 4 native camera resolution) to 648 x 484 guaranteeing that no speed issues occurred.

Regarding vehicle detection, two different methods were tested, being the first one based on Cascade Classifiers and Haar-like features. This method was considered because it has been demonstrated to be successful detecting cars from various angles [56].

The Classifier used was created with 150 positive car images and 250 negative images with 128 x 128 pixels. The results were fairly positive in some cases regarding the rate of detection (figure 5.6).



Fig. 5.6 – Cascade Classifier car detection

Unfortunately when testing this method two problems arisen: cars' side views would always give bad results and the method was extremely slow on iPhone 4 hardware. The first problem was handled by limiting the possible view angles that the detection would be possible, again taking into account the context of this thesis this workaround was acceptable. The second issue was more difficult to solve. Multiple approaches were taken (e.g. reduce image resolution, increase the factor by which the search window is scaled between the subsequent detection scans, increase the dimension of the search window) without success.

Execution speed is extremely important for a user driven mobile application that contains a real time game activity. If ease of use and quick response speeds are not met the user may experience frustration or boredom, significantly reducing the success of the persuasive effect pretended. Having the aforementioned in mind, another method was experimented, which approached car detection in a similar way that was done with airplane detection.

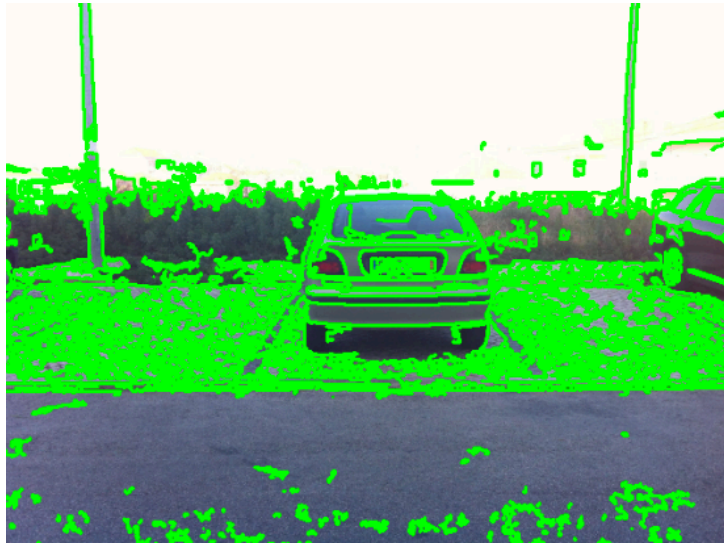


Fig. 5.7 – Contour based car detection

A contour based method for car detection was designed (figure 5.7). Several problems were immediately identified: different cars had different contour shapes and the background did not have a colour uniformity, introducing a lot of noise when processing the image. To help solve this problem the detection would not focus on detecting the cars but their plates. This would guarantee that the application would always search for something with a linear form independently from the car type and background.



Fig. 5.8 – Contour with four edges detection

To achieve what was previously mentioned we firstly eliminated the contours that were not constituted by four edges (car plates have four edges) like showed by the figure 5.8. Unfortunately

some false positives still persisted thanks to background irregularities. To solve this problem, the plate form factor was taken into account:

- The value of the angles between each edge is always 90° .
- Plate's height and width is constant and related to each other by a certain factor,



Fig. 5.9 – Plate Detection factoring edges' angles

Factoring the edges' angle was possible to eliminate most of the false positives, but some still prevailed (figure 5.9), again due to background irregularities and because a margin was given for each angle to improve detection (the angle considered was not exactly 90°).



Fig. 5.10 – Plate Detection factoring edges' angles and the relation between height and width

After factoring the ratio between regular plate's height and width the results improved and the detection was almost completed (figure 5.10). The only downside was that sometimes the rear lights and front bumper would give a false positive, but this could be ignored seeing that both were part of the car, which we were trying to detect.

The next step was to build a bounding box highlighting the car (environmental threat). To achieve this, the position of the car's plate relatively to the car itself was taken into account. The plate was considered to be a little bit down of the central point of the car and a bounding box was built from there.



Fig. 5.11 – Car Bounding Boxes

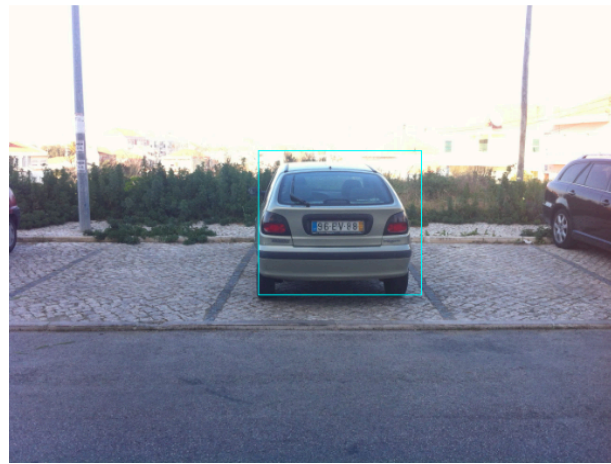


Fig. 5.12 – Car Final Bounding Box

In order to delete the bounding boxes from the rear lights or front bumpers, it was calculated which bounding box best represented the car area (figure 5.11). This was achieved by taking into account bounding boxes' area and position relatively to each other. Figure 5.12 shows the final result.

The decision between using the airplane detection method or the car one was designed to take into account how the user holds the iPhone 4. This was possible thanks to the device's accelerometer: if the user is pointing to the sky the first method is used, in every other situation the second one is used.

Even after all the work conducted to achieve a certain level of success when dynamically detecting environmental threats the false positives could not be totally eliminated. They were further reduced during the usability tests, because the characteristics of the location where test took place was taken into account (e.g. building colour or structure, lightning conditions, etc.) and controlled. Having in mind that this thesis is not focused in image processing, we think the work done was sufficient to ensure the validity of the tests conducted and their results regarding the persuasive effect pretended.

5.1.2 eVision's Interface

Next, we describe the interface of eVision integrating all design decisions. Each interface screen is described step by step highlighting the more important aspects of each one.

- *Introduction and Main Menu*: the first screen the user experiences when running the mobile application is the introduction screen (figure 5.13). This screen was thought to be minimalist, with only the application's logo and name. eVision's logo was carefully designed in order to represent the main feature of the application, a futuristic eye with eVision's main colours representing the alternate vision conceded through the application. Around it, we can find a hand changing the Earth course. This last part represents the power conferred to the users: people can change the world, in this case by being more environmental aware.

As described in chapter 3.1, figure 5.14 is the main menu interface and it is used to allow navigation between all the eVision's menus and features. The colours used on this interface represent the main colours of the application and establishes a pattern used in the rest of eVision to promote interface consistency and ease of use.



Fig. 5.13 – Intro

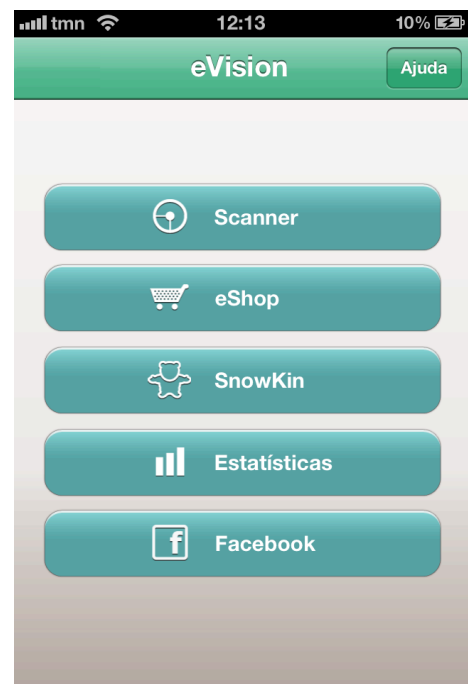


Fig. 5.14 – Main Menu

- *Help instructions*: the instructions interface was built to help the users to get in touch with eVision's functionalities and the virtual character. It was important to peek the user's interest, so instructions were designed to be visually appellative and introduce the user to Snowkin, which is the reason why most of the screens have the Snowkin present in one way or another. The help section was divided in four sub-sections: eVision's general description and purpose, Score System, Items and Customization, Facebook Integration.

- General Description - this subsection was created to present the user with a brief description of eVision and it's purpose. Snowkin makes its first appearance here with some items equipped, giving the user a brief look of what could be the appearance of his Snowkin.
- Score System - this subsection presents the score system, explaining how a game activity level is completed. This information is crucial to give the user a purpose to play and keep the interested in eVision game activity.
- Items and Customization - briefly describes the purpose of green leaves (in-game currency) and the use of items for customizing Snowkin.
- Facebook Integration - the eVision's Facebook features are briefly described.



Fig. 5.15 – eVision Description



Fig. 5.16 – Score System and Progression



Fig. 5.17 – Items and Customization



Fig. 5.18 – Facebook Integration

- *Facebook Menu*: this interface is responsible for handling the Facebook features available on eVision. When the user enters this menu for the first time, a login box will appear where the user can enter his Facebook credentials (figure 5.20). After verifying the user's credentials, the button to publish statistics on his wall and the Like button for DEAP Project Facebook page will be available, a profile picture of the user will also appear in the frame held by Snowkin (figure 5.21). The presence of Snowkin in this interface holding the user picture is not a coincidence, it was designed this way in order to take advantage of the fact that this section has a personal value (e.g. profile picture, user's name, etc.) making possible to deepen the bond between Snowkin and the user.

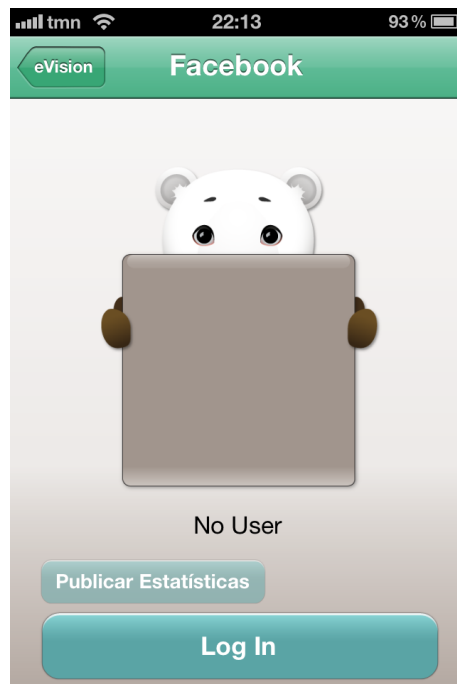


Fig. 5.19 – No user logged in



Fig. 5.20 – Login Interface

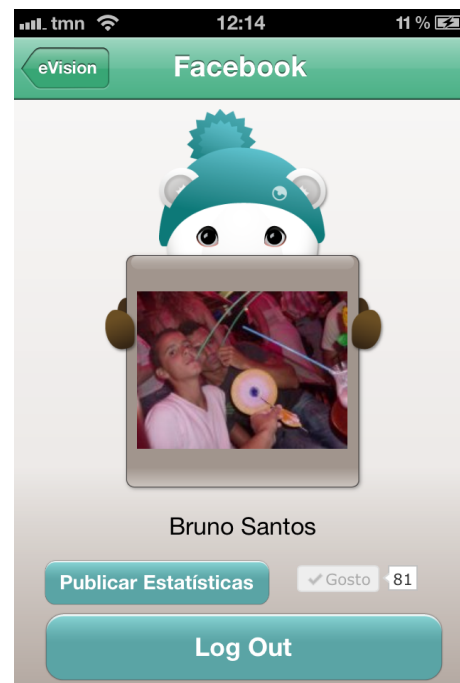


Fig. 5.21 – User Logged In

- *Scanner Mode*: the main feature of eVision, the Scanner, provides a place for gathering information regarding environmental threats, as well as start the game activity presented on the application. Different types of environmental information is presented, being the data regarding air quality always presented on the upper right corner of the screen (figures 5.22 to 5.25). The environmental threats are presented on screen when the user points the camera towards one industrial factory near his location (figure 5.23). Information about factories is given on a smoke cloud to represent the pollution effect caused by them.

When the user touches the screen as hinted on the message on figure 5.25, Snowkin appears to invite him to participate in the game cleaning activity. Note that Snowkin always addresses the user by his name (Facebook login needed) and with a happy and cheerful tone to persuade the user to engage in the activity. At any given time the user can leave the Scanner mode by clicking the “pause” button and choose to quit (figure 5.23).

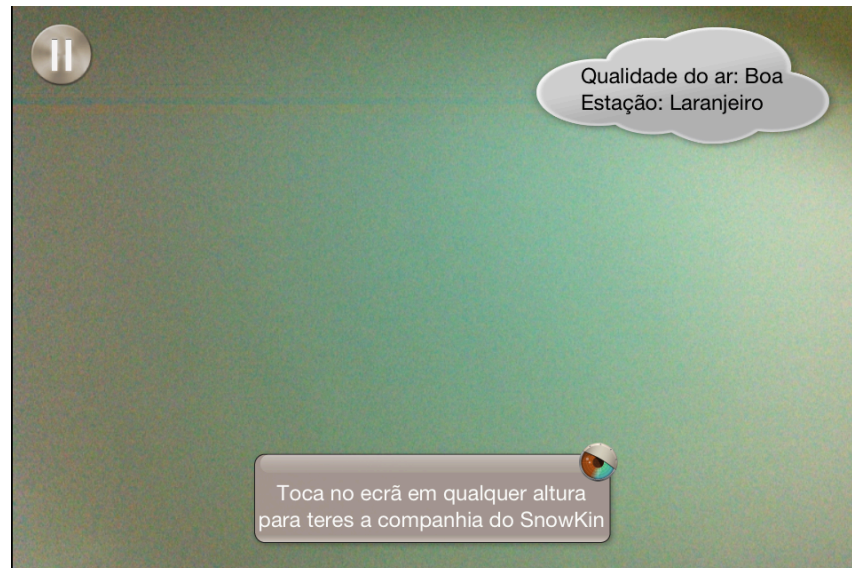


Fig. 5.22 – Scanner Mode



Fig. 5.23 – Scanner Pause Menu



Fig. 5.24 – Factory detected



Fig. 5.25 – Snowkin showing in Scanner Mode

- *Game Activity*: If the user accepts the invitation to participate on the game activity made by Snowkin, a countdown will appear and the activity starts (figure 5.26). A score gauge appears on the upper right corner and a “capture image” button with eVision’s logo, to snapshot the user’s surrounding environment, shows up on the bottom left corner. Snowkin assumes his motivational role and pushes the user to find environmental threats.

When a threat is detected Snowkin warns the user so he can clean it, note that the Snowkin expression is contextualized with the situation (figure 5.27). After the detected threat is cleaned Snowkin immediately congratulates the user and motivate him to keep going, the score gauge is also filled depending on the value of the threat cleaned (a greater area will be filled according to the score value of the eliminated threat) as shown on figure 5.28. Again it is

important to notice that when cleaning threats Snowkin's expression changes adapting to the situation context, in this case a happy face. After the Score gauge is fully filled the level ends and Snowkin praises the user. A Score table is also shown discriminating the values that were factored to calculate the final score (green leaves), which represents the currency gained to purchase items. This moment, when the user is focused on the screen, is exploited to apply persuasion by giving the user information about his action effects on environment and trivia related to hazard effects that air pollution cause on the environment (figure 5.29).



Fig. 5.26 – Activity Start



Fig. 5.27 – Car detected



Fig. 5.28 – Threat Eliminated



Fig. 5.29 – Activity End

- *eVision Store (eShop)*: This feature allows the user to spend the green leaves earned playing eVision's gaming activity. A list of items is presented in a visual appealing way using a small icon to represent each item, showing the item's name and slot and its price in green leaves (figure 5.30). The user's leaves balance is shown on the upper right corner of the screen and the items that were already bought have a Snowkin icon.

When the user selects an item a preview of it equipped on Snowkin is shown. This allows the user to check the item appearance before committing on the purchase (figure 5.31). Even when the user decides to buy the item a confirmation box will appear with the item's price and the user's current balance. The purchase method was designed this way to avoid possible user

errors (purchasing the wrong item), decreasing the chances of frustration and increasing the usability of the interface.



Fig. 5.30 – eShop



Fig. 5.31 – Item Preview



Fig. 5.32 – Purchase Confirmation

- *Snowkin Menu*: The last interface feature related to Snowkin is the one where the user can customize its appearance. As previously stated the commitment and time the user puts on

building Snowkin's appearance makes him more likely to follow the character's advices and recommendations about the environment thus being persuaded by the application. In figure 5.33 every column represents an item slot (head, torso, legs, feet and hands), the slot machine style selection is very intuitive and avoids the danger of simultaneous choosing two items of the same type.

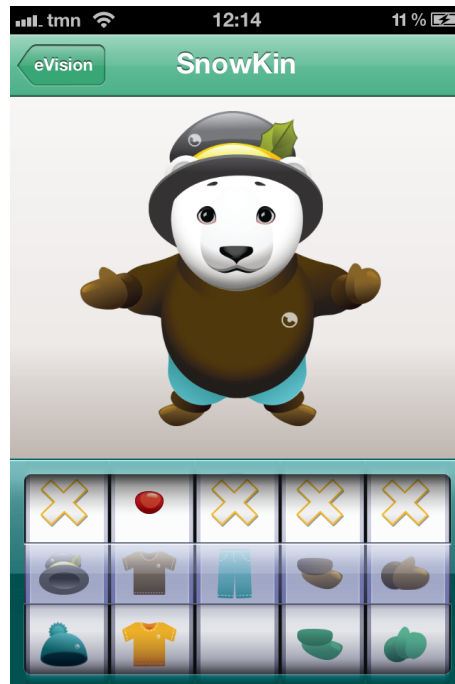


Fig. 5.33 – Snowkin Customization

- *Statistics*: This option presents the user with statistics gathered throughout the time spent using the application. Statistics building confer a sense of pride that can also make the user come back and repeat the use of eVision thus opening more persuasion opportunities.



Fig. 5.34 – Statistics

5.2 Implementation

As previously described, eVision was implemented mainly using the Objective-C language, with the exception of the image processing classes, and Xcode IDE. Since it is nearly impossible to describe all implementation components and features with great detail, only important ones will be presented in more detail. Each class is composed by an header (Class.h) that contains the declaration of global variables and methods, and a implementation file (Class.m) which contains the proper class methods implementation. Interface builder files (eVision.storyboard) will not be presented, since they only hold information regarding the interface elements. There are still three files responsible for holding data related to user's statistics, eShop items information and static environmental threats coordinates and information.

Table 4 presents each Class and corresponding general description:

Classes	Description
eVisionDelegate	Class that has the normal Application Delegation role of every system developed for iOS with the particularity that it is here where the database for eVision is created when the application is booted for the first time.
MainViewController	Class responsible for the main menu implementation. This class manages all the other interfaces and keeps track of the user location inside eVision. This class also becomes the

Classes	Description
TutorialViewController	<p data-bbox="620 248 1366 376">ScannerViewController delegate, receiving information about the user's progress regarding the game activity and updating the other interfaces.</p> <p data-bbox="620 416 1366 495">This class presents the user with eVision's instructions and allows scrolling between pages using touch-based gestures.</p>
ScannerViewController	<p data-bbox="620 533 1366 862">This class is the most important of the mobile application, it interacts with many other classes inside the application and it is responsible for the Scanner main functionality. It is responsible for managing the device camera and capturing the images, which will be processed to dynamically detect environmental threats. It also manages the Snowkin's dialogue and user's interaction with it.</p> <p data-bbox="620 902 1366 1738">One particular aspect of this class is the conversion from latitude, longitude and altitude to screen pixels. This is used to represent the location of a static environmental threat on the iPhone's screen and it is not a trivial thing due to the fact that, given eVision's context, the conversion has to be made from a 3D space to a 2D one (screen). We use the heading given by the device's compass in conjunction with latitude and longitude to determine if the user is facing a environmental threat, this gives us the information about the threat's x coordinate on screen. The threat's screen y coordinate is more difficult to determine. Using the values provided by the device's accelerometer, we calculate the device angle with the ground and in conjunction with the threat's altitude the y coordinate is discovered. It is important to notice that the environmental threat dynamic detection method is also decided in this phase, using the accelerometer to find if the user is pointing to the sky.</p> <p data-bbox="620 1778 1366 1854">In short this class is responsible for applying the Augmented Reality effects pretended for this application.</p> <p data-bbox="620 1895 1366 1971">This class is also responsible for starting and ending the game activity, as well as managing the current level where the user</p>

Classes	Description
ImageViewController	<p>is playing and the time spent on it.</p> <p>Class that handles all actions related to the snapshot taken by the user in Scanner Mode. This includes the highlighting of threats detected by the ImageProcessor class and Snowkin dialogue management regarding cleaning them. This class also informs the ScannerViewController about how many threats were cleaned and how it influences the current level progression.</p>
ActivityViewController	<p>Class that handles the game activity end screen by showing the user's score, consequences of his actions and environmental trivia. This class also allows the user to move to the next level.</p>
ShopViewController	<p>Class that loads the items database and is responsible for the eShop interface. When the user selects an item the class sends information regarding it to the ItemViewController class.</p> <p>This class also calculates the user current balance and what items have been already bought.</p>
ItemViewController	<p>Class that handles the preview of the item selected for purchase. Any alterations on the green leaves balance are also manage by this class, properly saving them in eVision's database.</p>
SnowkinViewController	<p>Class that handles Snowkin customization using the slot-machine type of interface. All items available for Snowkin customization are loaded from the database.</p>
StatisticsViewController	<p>This class presents the user statistics based on information presented on eVision's database.</p>
FacebookViewController	<p>Class that handles all features related to eVision's Facebook implementation. This is achieved using the Facebook Mobile API. The class extracts the user's real name and profile picture from Facebook to use them throughout the application. This is also the place where is created the text which will be shared in the user's Facebook Wall. It is important to note that the Facebook API does not natively support the "Like" button, because of this a Web View to contain a piece of HTML to</p>

Classes	Description
	simulate the Like button of DEAP Project Facebook page was created.
LocationProcessor	Class that is responsible to initiate the device's Location Manager. It also handles the Location and Heading updates of the iPhone.
LocationTools	Class that converts the database information regarding threats' location to geographical coordinates capable of being used by the iPhone. This class also calculates threats' azimuth that is relevant to represent them on screen when the user is in Scanner Mode.
ImageProcessor	Class that handles the methods described on chapter 5.1 for dynamic threat detection. It receives the snapshot taken by the device's camera and applies one of the two implemented methods (airplane detection, car plate detection) and returns to the ImageViewController the screen coordinates of all bounding boxes regarding the threats detected.
ScratchGestureRecognizer	Class that handles the recognition of the touch gesture needed to clean a threat. It tracks the user's finger movement on screen and, using its direction and speed, determines if the gesture done is enough to clean the environmental threat.
ScratchView	Class that is created for every detected environmental threat's bounding box. Allows to create the scratch card effect, so when the user is cleaning a threat his finger will be drawing the overlay which is suppose to replace it.
Effects	This class was implemented just to create a particle effect that represents the user's finger movement on screen when he is participating on the game activity.
VehicleClass	Class that represents a vehicle on the eVision implementation, saving its bounding box screen coordinates.
LevelClass	Class that handle the level structure of the game activity (e.g. how many points are worth each type of threat, how many points are needed to finish a level, how many levels exist,

Classes	Description
	etc.).
StoreItem	Class that represents an item on the eVision's implementation, it contains the item's name, type, image, price and information regarding if it was already bought or not.
TimeCounter	Class that handle the countdown before the game activity starts.

Table 5.1 – eVision's implementation classes

5.3 Usability Tests

When developing interactive systems, usability tests are of great importance because they allow the evaluation of a product by testing it with users. Evaluation techniques measures the ease of use of the product by giving direct input on how users use the system, also allowing to detect errors and areas to improve in terms of user interaction.

5.3.1 Methodology

Throughout eVision's development some small-scale usability tests were conducted to assert specific interface components and functionality. Although useful, these tests were not enough to proper evaluate how people would use and be affected by the application, because of its peculiar functionalities (geographical reference data and vehicles dynamic detection). To overcome these shortcomings and assert how people was affected by eVision, usability tests based on a live setting were carried out with a diverse group of twenty participants. The final usability tests took place in three distinct locations: Seixal and near the Lisbon airport.

The first tests were carried out in Seixal to a group of trainees of Cérebro – Formação e Consultoria Lda between 5 p.m. and 9 p.m., which were times with a good lighting setting. The tests were conducted with one participant at a time. A small briefing explaining the context and functionalities of the mobile application took place and, after that, a small example showing the eVision working was given to help people unfamiliar with the iPhone device. The participants had twenty minutes to use the application at their convenience (always with the application purpose in mind). In general, the tests went well, with occasional false positives detected that did not hindered the user experience. Most participants felt motivated to go on and wanted more time to continue experiencing the eVision. The Snowkin character had a particular strong impact, driving the participants to keep getting points, so they could buy more items to customize it and making some of them actually sad when the test was over and they had to say goodbye to Snowkin.

In the end of each test, a questionnaire, which can be found in the annexes of this thesis, was given to each participant to evaluate the eVision's usability, as well as the persuasive effect pretended.

The second tests were conducted near the Lisbon airport, following the same methodology as the previous ones. These tests were conducted because in the previous tests airplanes were not a common occurrence, which made the usability tests somehow incomplete. To fix this, a group of tests were carried out near Lisbon airport where multiple airplanes fly by. These tests also went very well with no relevant differences in results when compared with the previous one, except the fact that airplanes were detected on all participant sections.

In total, eVision was tested by twenty participants (50% men). Users had ages between 18-56 years old (mean = 30.9). 10% of users had MSc degrees, 40% had BSc degrees and 50% had not any higher education. Of all participants 30% were students, 20% were unemployed and 50% were full time workers.

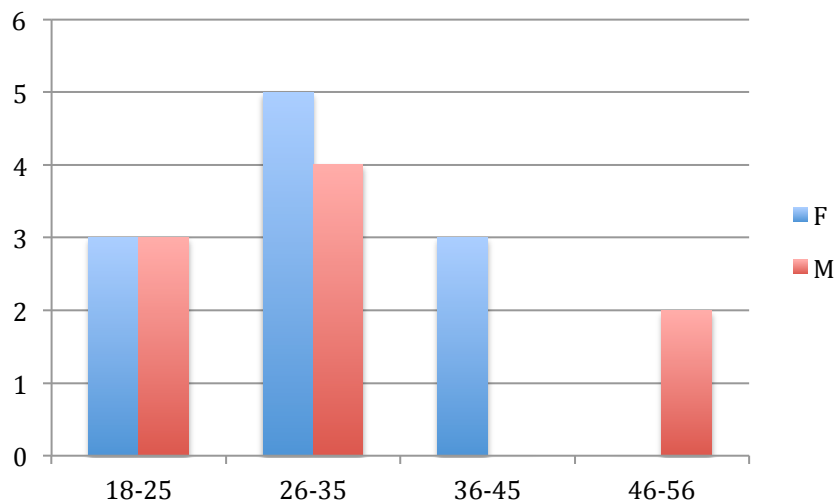


Fig. 5.35 – Numbers of participants distributed by their age group according to sex

5.3.2 Questionnaire Structure

Participants responded to a questionnaire consisting of six sections. Section one was a demographics section comprising five questions on participants' age, gender, educational qualification, profession and e-mail address. In this section we also accessed the environmental profile of participants based on their opinion toward three statements. Participants indicated their agreement or disagreement with each item on a five-point Likert scale ranging from (1) totally agree to (5) totally disagree.

Section two refers to New Technologies. Participants indicated how often they use the computer, game consoles, mobile phone, internet or other technology using a scale that varies between (1) daily and (5) never.

In section three participants evaluated the application. The participants evaluated the General Aspects of the application, as well as its usability and ease of use based on the rate of agreement with three statements using a five-point Likert scale ranging from (1) totally agree and (5) disagree. Users also rated how easy it was to execute the ten main eVision functionalities using a five-point Likert scale ranging from (1) very easy and (5) not performed this functionality.

In the fourth section of the questionnaire, participants were asked about their experience as users of the eVision. This section of the questionnaire was based on the Microsoft “Product Reaction Cards” [57, 58]. 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 as users of the application, from a selected set of words.

The fifth section refers to Snowkin. Participants indicated their opinion about eight statements. In six of them, users had to indicate their degrees of agreement using a five-point Likert scale ranging from (1) totally agree and (5) totally disagree. The interaction with the Snowkin was evaluated with a five-point Likert scale ranging from (1) extremely nice and (5) extremely unpleasant. At the end of this section, the participants indicated their perception of Snowkin role among five possibilities (e.g. a friend, a team mate, etc.).

In the last section of the questionnaire users were invited to contribute with a suggestion, a comment or a recommendation to improve the application.

5.3.3 Results' Discussion

Participants' Profile

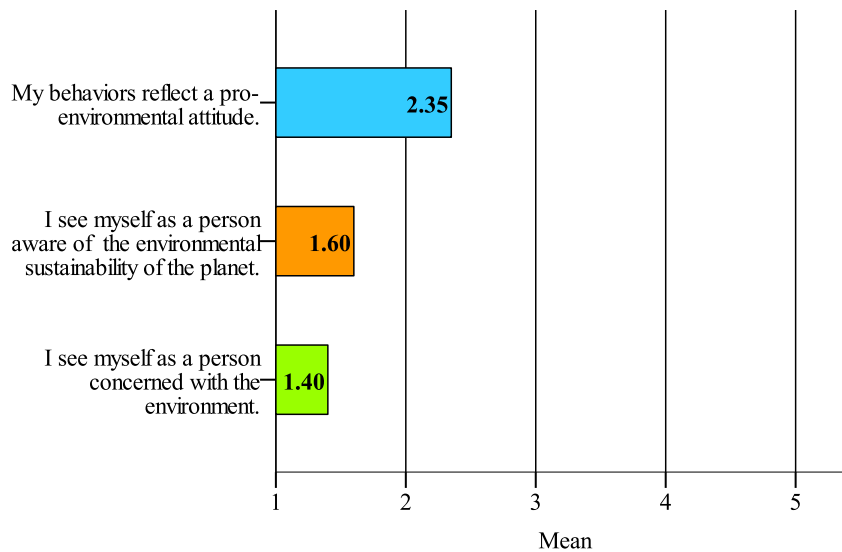


Fig. 5.36 - Environmental profile of participants

Based on the participants' opinions regarding the statements in section one of the questionnaire, we inferred a strong pro-environmental profile. As figure 5.36 shows, the average rate of agreement towards the first three statements indicated that participants totally agree (mean = 1.40) that they were "concerned with the environment". They also agreed that they were "aware of the environmental sustainability of the planet" (mean = 1.60) and that their "behaviours reflect a pro-environmental attitude" (mean = 2.35). Despite of the positive results regarding pro-environmental behaviours, the difference highlighted in the figure 5.36 shows that their behaviours might not reflect such pro-environmental attitudes. This could be due to social desirability, which shows a tendency for individuals to chose the answers valued by society and reject those that are socially undesirables, rather than answering accordingly to what they believe apply to themselves.

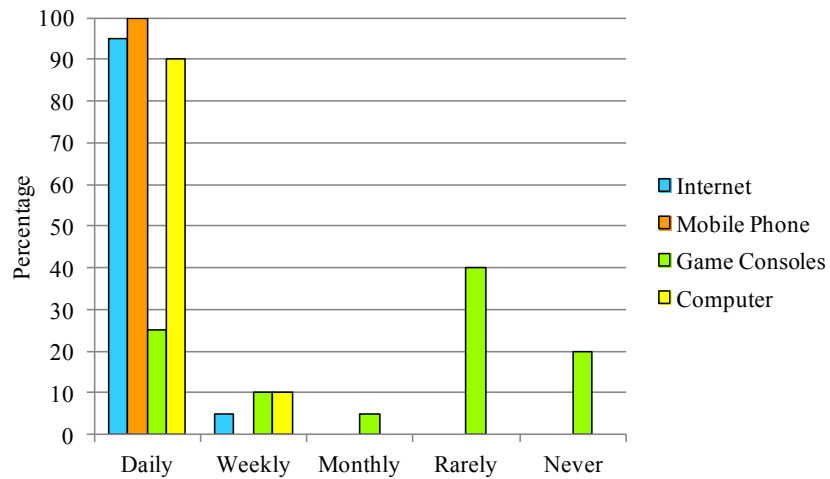


Fig. 5.37 – Use of New Technologies

All participants were familiar with New Technologies. In general, participants used new technologies on a daily basis, such as the computer (90%), mobile phone (100%) and Internet (95%). Only game consoles are used less often with only a few participants using them on a daily basis (25%). None of the users mentioned the use of any other type of new technology.

eVision's Evaluation

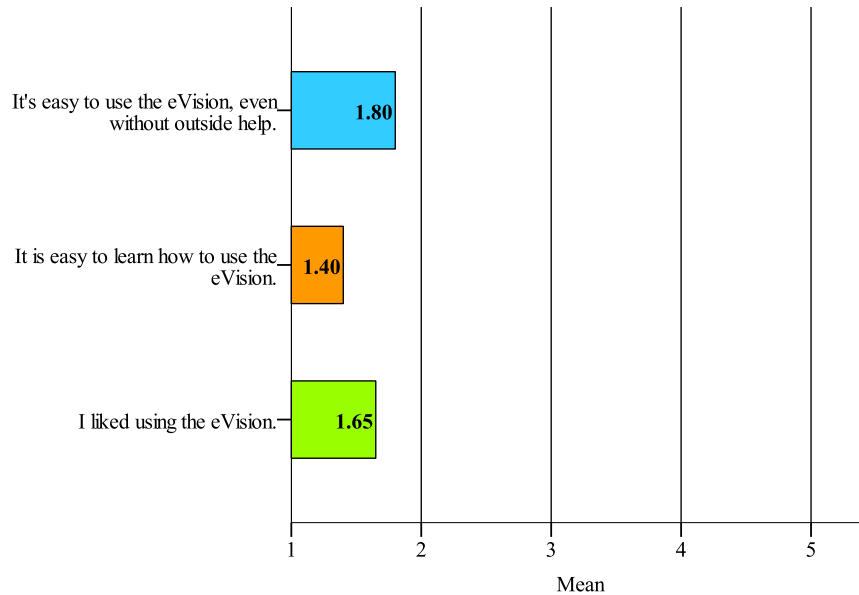


Fig. 5.38 – Evaluation of eVision's general aspects

The overall assessment of the application was very positive. Users liked to use the application (mean = 1.65) and agreed that it was easy to learn how to use (mean = 1.40) and to use it even without outside help (mean = 1.80).

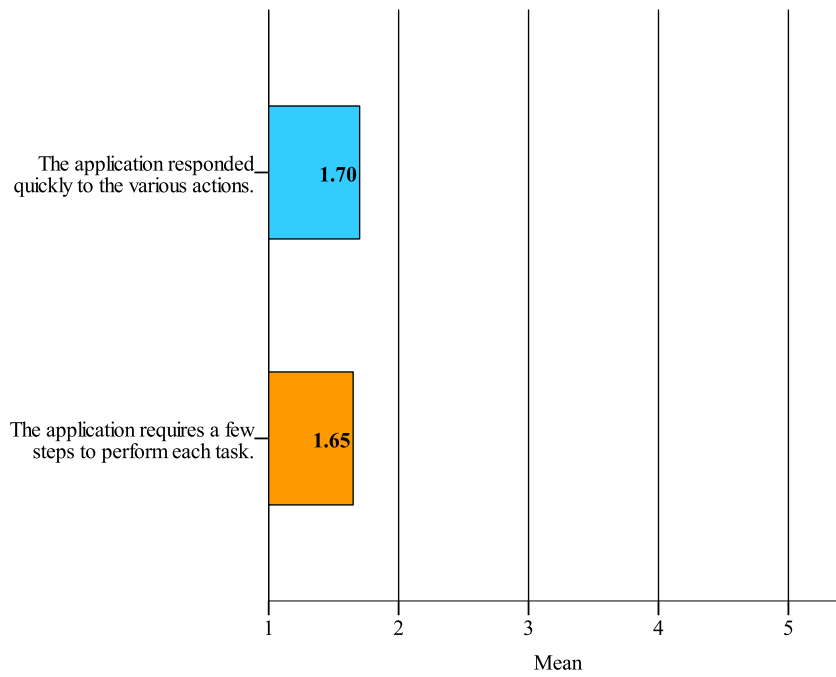


Fig. 5.39 – eVision’s usability and ease of use

Participants agreed that eVision responded quickly to the various actions (mean = 1.70) and that it required a few steps to perform each task (mean = 1.65).

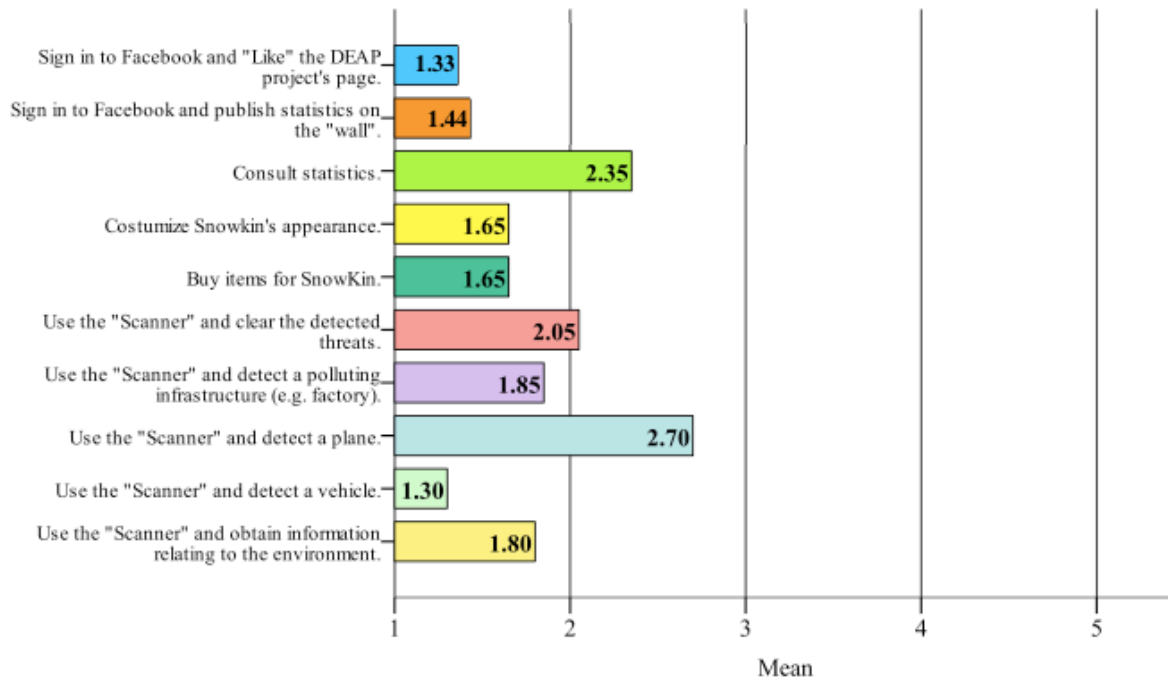


Fig. 5.40 –eVision’s features usability and ease of use

Regarding ease of use, users found very easy to detect a vehicle (mean = 1.30), while the detection of a polluting infrastructure (mean = 1.85) or a plane (mean = 2.70) was more difficult. In an urban

area (such as that in which the application has been tested) vehicles circulated frequently being more common to find a vehicle than to see a plane. The same happened with the polluting infrastructures. The difference may have reflected simply the largest presence or absence of these elements in the area in which the application has been tested. Anyway the participants considered easy to obtain information relating to the environment (mean = 1.80), as well as to clean any detected threats (mean = 2.05). Use the “Scanner” to detect and clear environmental threats is the user’s main mission. If it is perceived as an easy task, this opens the door to apply the persuasive suggestion concept. Consulting statistics regarding users performance was also perceived as being easy to execute (mean = 2.35).

The participants also considered easy to buy items for the Snowkin (mean = 1.65) and customize its appearance (mean = 1.65). This could help enhance the persuasion through the persuasive tailoring concept.

The two statements relating to Facebook have to be discussed more carefully given that most participants did not signed in to Facebook, such is shown by the results of question 4.5 and figure 5.43. Thus, the obtained results would reflect more the impact of option 5 ("not performed this functionality") chosen by many users than the real difficulty of signing in to Facebook and use its features. So for this part of the discussion the participants who did not use the Facebook feature were not considered. Those who used these functionalities found them easy to use: “Like” the DEAP project’s page had a mean of 1.33 and publish statistics on the “wall” had a mean of 1.44.

User experience

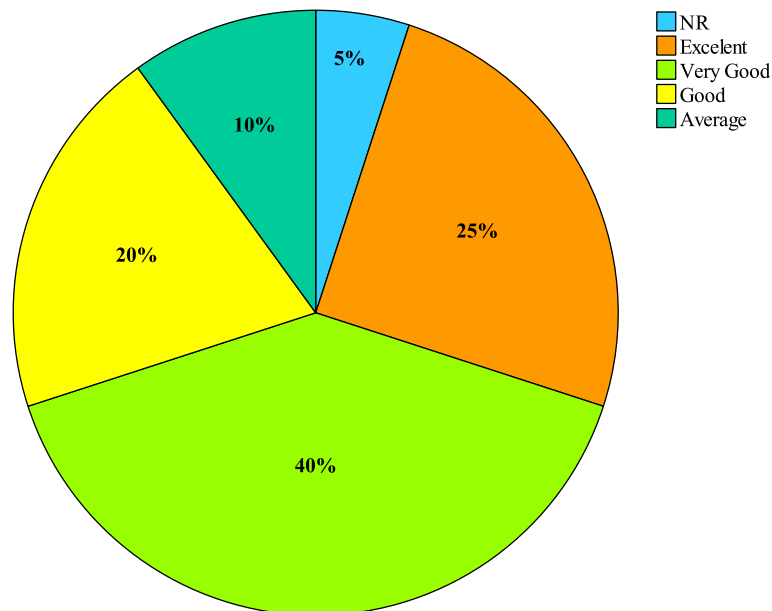


Fig. 5.41 – General opinion about eVision

Users enjoyed the experience when using the eVision: 40% of participants rated the experience as being "very good" and no one felt that it had been "bad". Enjoying the use of eVision is

psychologically positive and is an incentive to repeat the experience thus creating more opportunities for persuasion.

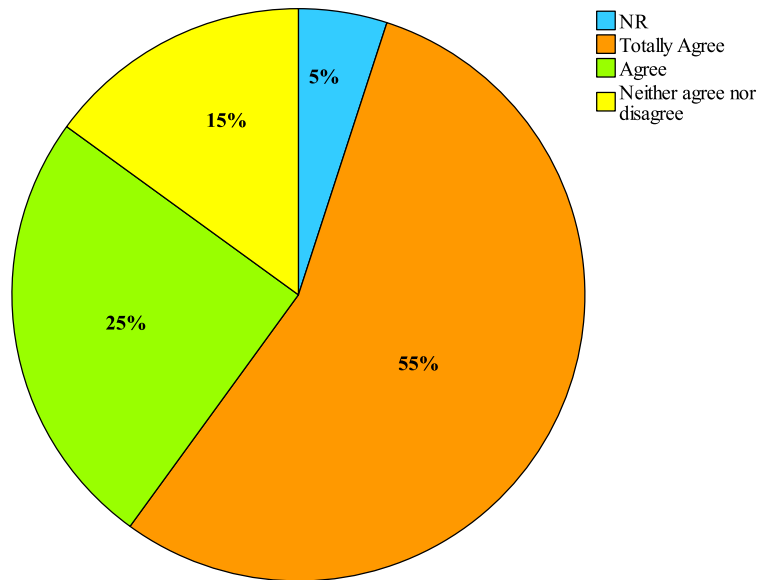


Fig. 5.42 – Rate of users who found that eVision increased environmental awareness

The fact that 55% of participants considered that the use of the application contributed to increase their awareness of environmental issues demonstrates the persuasive potential of the eVision. Self-monitoring and conditioning (mainly through Snowkin as we will discuss when analysing the results of the fifth section of the questionnaire) might have persuaded users to adopt pro-environmental behaviours or attitudes. Additionally, cause-and-effect scenarios allow the users to see the consequences of their actions allowing eVision to persuade them in subtle ways.

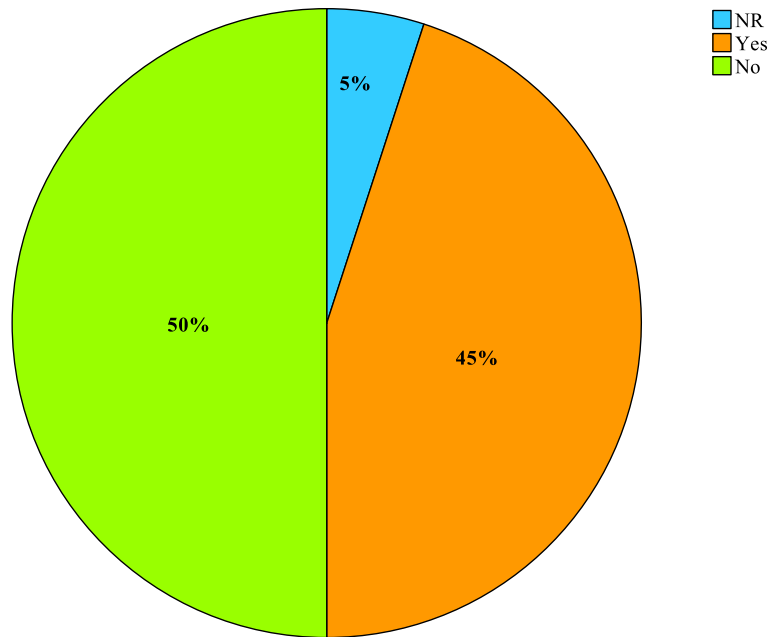


Fig. 5.43 – Facebook use

As mentioned previously, most of the participants (50%) did not have signed in to Facebook. This made the experience less customized for these users and this also might have decreased the persuasive capacity of eVision due to a minor tailoring effect (e.g. Snowkin could not address the user by his main name). The reasons why users did not signed in on Facebook through eVision will be covered when discussing the impact results.

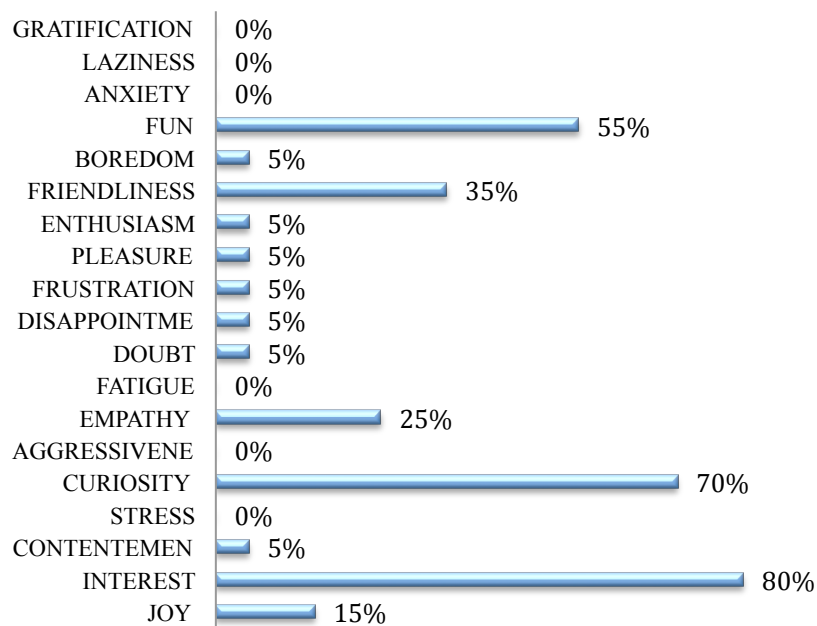


Fig. 5.44 – Emotions raised by eVision

The emotions raised by the use of eVision were mostly positive which is good because it encourages repetitive use and increases the persuasive potential of the application. From all the participants, 80% felt interest and 70% felt curiosity. Furthermore, most participants felt other positive emotions, such as fun (55%), friendliness (35%), empathy (25%) and joy (15%). Emotions such as friendliness and empathy show a relational dimension that demonstrates the social role assigned to Snowkin and consequently ensuring it a greater persuasive power. Fun and joy are also relevant, because these are important features for an application that contains a game activity.

Negative emotions such as boredom, frustration and disappointment were also experienced but only by a non-significant number of participants (5%).

Snowkin

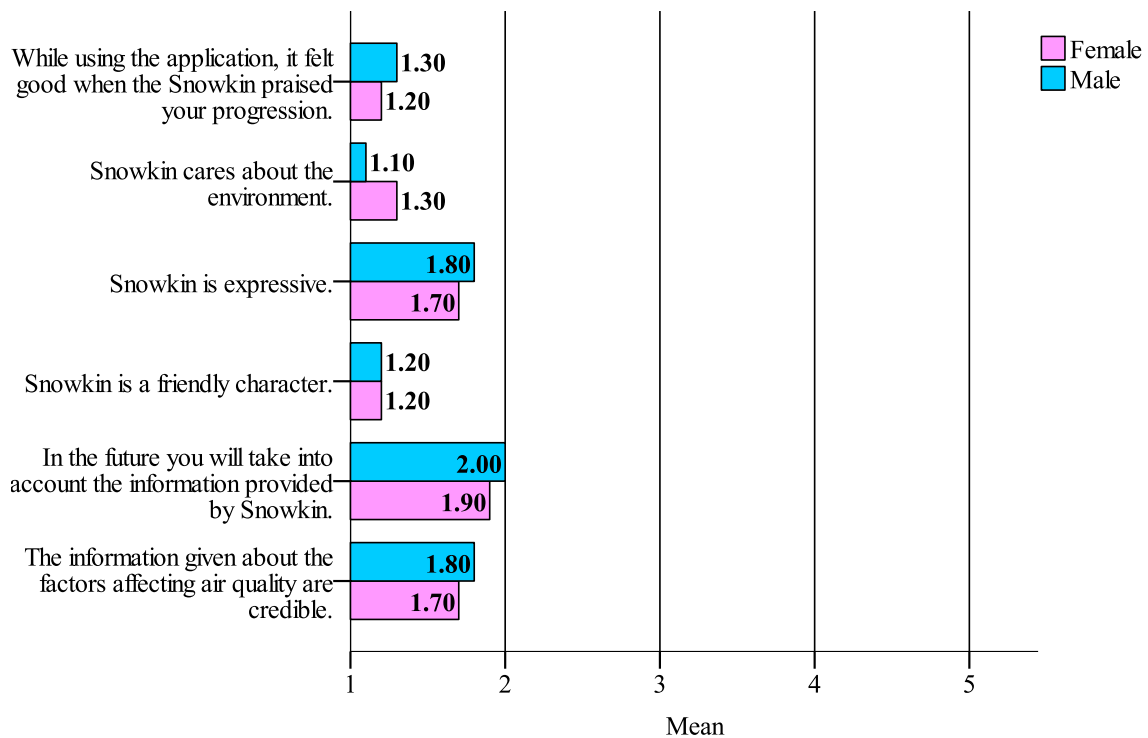


Fig. 5.45 – Users’ opinion about Snowkin

The participants’ opinion about the Snowkin was not significantly different between men and women ($p > 0,05$ to all the statements, using Mann-Whitney U test, a non-parametric significance test for two independent samples – the full results are shown in annexe 8.1). In general, the feedback from users was positive and congruent with the image that we wanted to create for a virtual character. On average, users agreed that Snowkin cares about the environment (men’s mean = 1.10; women’s mean

= 1.30), it is a friendly character (mean = 1.20) and they felt good when the Snowkin praised their progression (men's mean = 1.30; women's mean = 1.20).

Users also agreed that Snowkin is expressive (men's mean = 1.80; women's mean = 1.70), the information given about the factors affecting air quality are credible (men's mean = 1.80; women's mean = 1.70) and in the future users will take into account the information provided by Snowkin (men's mean = 2.00; women's mean = 1.90).

These results showed the great potential of persuasion present in eVision through Snowkin, which can put into practice not only the tailoring as we have discussed previously, but also conditioning by pleasantly praising user's progression. As a social actor, Snowkin is also very effective: it has not only the right physical cues (e.g. expressiveness), but also the right psychological (e.g. cares about the environment) and social traits (e.g. friendly). Additionally, useful and credible information reinforces eVision's social role.

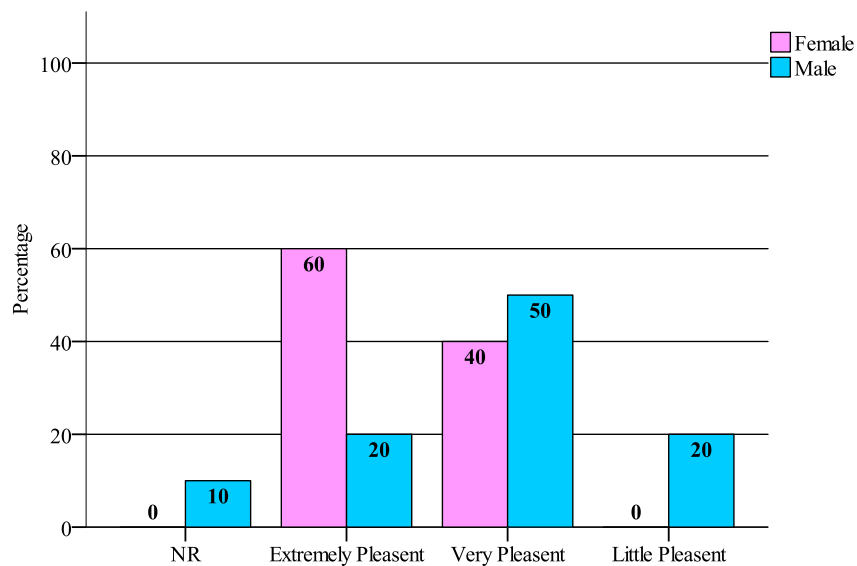


Fig. 5.46 – Interaction with Snowkin

The interaction with the Snowkin was considered extremely pleasant by most women (60%) and very pleasant by most men (50%), which was very positive because it contributes to the repetition of the experience increasing the opportunities for applying persuasion.

Also regarding the interaction, although no one has considered the experience unpleasant (the option "extremely unpleasant" was suppressed in the figure 5.46), in general women had a more positive opinion than men (20% considered the experience little pleasant and 10% have not answered this question).

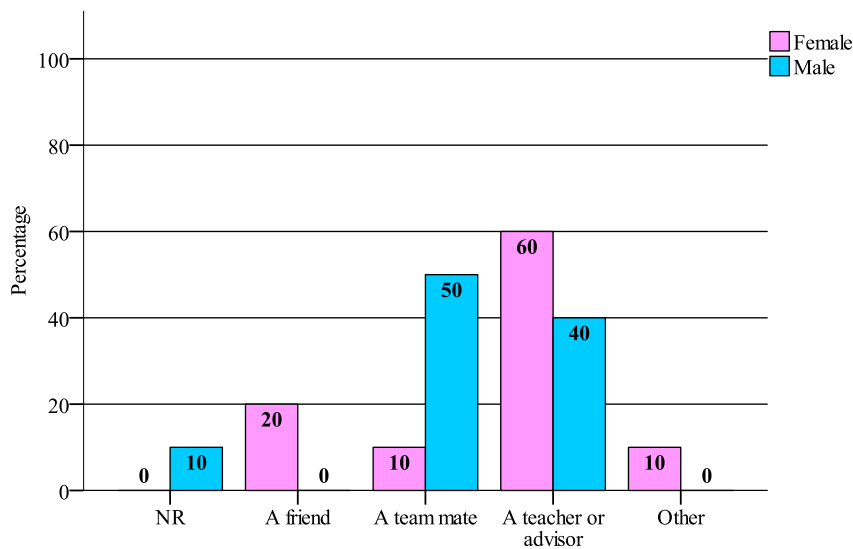


Fig. 5.47 – Users' perception of Snowkin

The Snowkin was considered a teacher or advisor for the majority of women (60%). Women considered it also as a friend (20%), as a teammate (10%) and as "a friendly character" (10%). On the other hand, men considered it only as a teammate (50%) and as a teacher or advisor (40%) – 10% of men have not answered this question.

It is important to note that most women did not have signed in to Facebook and that is why the Snowkin could not establish a relationship as tailored as it could be (e.g. Snowkin could not address the user by his main name). Perhaps this factor has contributed to the fact that the majority of women considered the Snowkin as a teacher or advisor while most men considered it closer (a team mate). Anyway, it is important to note that in all cases it was clear that the user has established a relationship with the virtual character (which performed a social role) and that the relationship established was always positive.

Participants' comments

Finally the participants made suggestions and recommendations to improve the application, such as: the role of items that can be purchased for Snowkin should be described; the boxes used to highlight the detected threats should be more appealing; the icons that appear after the cleaning of the detected environmental threats should be more diverse and the activities could be more challenging. Other users expressed their satisfaction with eVision: "I really enjoyed playing this game, because it gave me more information about the environment", "the idea is quite original and well developed", "I really enjoyed the experience", "very interesting research which combines the new information technologies to raise awareness of environmental problems".

5.4 Impact Testing

The questionnaire made to users after the evaluation tests helped to assess eVision's persuasive power but it was not enough. The persuasive effect intended was a long term one, so it was crucial to evaluate participants' behaviours and attitudes some time after they have experienced eVision. This would allowed us to acknowledge if users' were really persuaded by eVision to have better environmental behaviours or attitudes and if the designed persuasive elements fulfilled their role.

5.4.1 Methodology

Roughly one month after the usability tests were conducted, a questionnaire (presented in the annexes) was sent to participants (everyone who took part of the evaluation tests of the computational prototype) through e-mail. Every participant answered on different time intervals, some took only a couple of days while others took almost a full month.

5.4.2 Results' Discussion

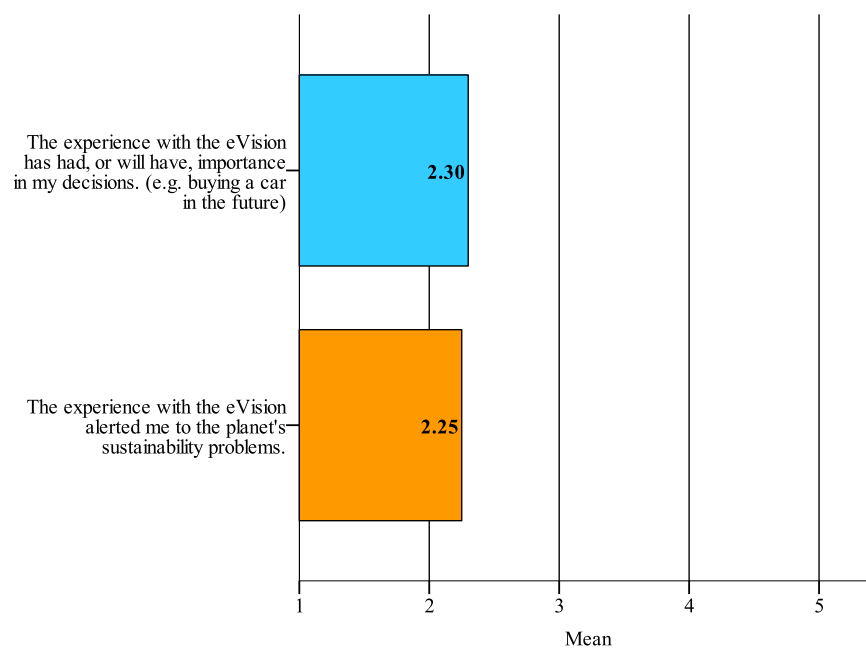


Fig. 5.48 – eVision importance on participants' attitudes or behaviours

The first questions were created to discover the effect of eVision's on participants' behaviours or attitudes towards the environment and their general awareness about sustainability problems. This questions were answered on a (1) totally agree to (5) totally disagree Likert scale. First users were asked to rate the importance of eVision's on their present or future everyday life decisions, and second

they were asked to rate their agreement with a statement about the eVision’s power to alert them about our planet’s sustainability problems.

As can be seen in figure 5.48, the results were positive, participants found that experiencing the eVision influenced or will influence their decisions that affect the environment in some way (mean = 2.30). Participants also agreed that eVision played an important role in alerting them to Earth’s sustainability problems (mean = 2.25).

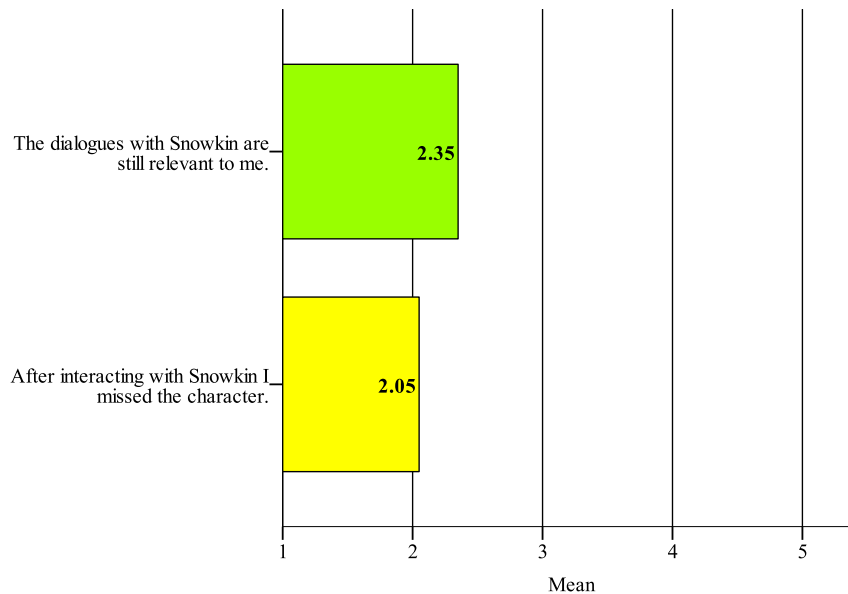


Fig. 5.49 – Snowkin lasting appeal

Another part of the questionnaire was made to reckon the importance of Snowkin on eVision. Users were asked to rate two statements, one regarding the importance of Snowkin dialogues to the users and other to see if participants missed interacting with the virtual character, both were answered on a (1) totally agree to (5) totally disagree Likert scale.

Figure 5.49 demonstrates that the results were again very positive, showing that participants still felt that Snowkin dialogues were relevant on the day they answered the questionnaire (mean = 2.35). Curiously the statement with a better rate of agreement (mean = 2.05) was the one stating that the participant missed Snowkin after interacting with it, showing the importance of the virtual character on the development and testing of the mobile application eVision.

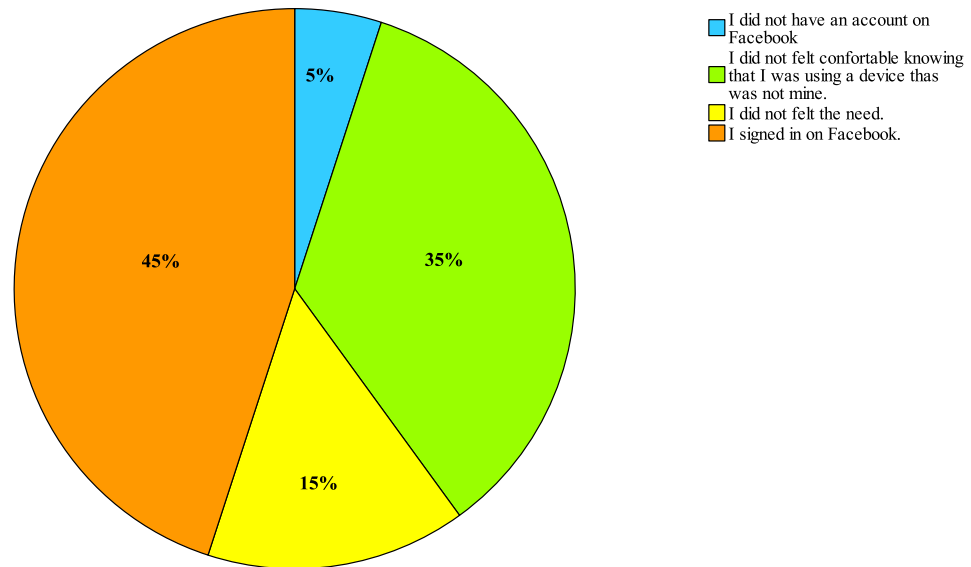


Fig. 5.50 – Reasons for the lack of use of Facebook features

Finally, participants were asked about the eVision’s Facebook features. This part of the questionnaire was not to assess eVision’s persuasive effect but to find out the reasons why participants did not use the Facebook features. As can be seen in figure 5.50, the major reason for not using Facebook when using eVision was the fact that users did not felt comfortable using confidential information on a smartphone which was not theirs (35%). Also 15% of the users interviewed did not felt the need or motivation to login, showing that maybe eVision could improve by having some sort of reward for users who used its Facebook features. A small percentage (5%) did not use Facebook simply because they did not have an account at the time.

Although the results were fairly positive it is maybe necessary to perform further tests to assert their accuracy, due to the fact that the impact questionnaires were applied in an online environment, making impossible to verify the participants answers as being real. Sometimes users answer the questions with what they perceive as being correct instead of what corresponds to the reality.

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6 Conclusion and Future Work

This dissertation presented the use of persuasive technology through mobile devices and Augmented Reality technology. The main goal was to make citizens aware of environmental issues in a fun and immersive way using mobile devices and augmented reality technology that was used to create an environmental scanner. This scanner provided the user with informative insight about the surrounding environment, while highlighting the environmental threats.

It was developed a mobile application called eVision, which included an environmental scanner with a game activity embedded, offering an alternative view of the surrounding environment in a fun and interactive way. The eVision application also introduced a virtual character named Snowkin, which interacted with users helping to persuade them to have better pro-environmental behaviours and making them aware of environmental threats in their surroundings.

In the end, user tests were conducted and their analysis revealed:

- *Good feedback about applying persuasive technology concepts*: most proposed persuasive concepts were successfully applied on eVision, revealing to be crucial to apply the persuasive effect intended.
- *eVision revealed to be an easy to use and fun application*: users found eVision to be easy to use even without outside help and generally provided a great experience.
- *Participants enjoyed the Augmented Reality based scanner and game activity*: eVision's scanner gave users a different view about their surroundings and also engage them on a fun game activity.
- *Users liked to interact with eVision's virtual character*: generally users appreciate Snowkin's feedback and the ability to customize his appearance.
- *Snowkin earned a social dimension as was intended*: users inferred personality traits to Snowkin and established a social relationship with it.
- *Generally eVision's effect on users still remained after some time*: participants still felt aware of sustainability problems mentioned by eVision and felt that it has or will have importance on their actions.

We believe that the work conducted on this thesis can act as a real persuasive technology to improve people's behaviour and attitudes towards the environment, as the evaluation tests shows. Moreover the work presented on this thesis will be presented on ACE 2012 at Kathmandu, Nepal, between 3 and 5 of November 2012.

6.1 Future Work

Although eVision showed positive results there are room for improvements regarding future work. The main areas are the following:

Detection of additional environmental threats

At the moment, it is possible to detect cars, airplanes and geo-referenced factories, but it would be interesting to add more environmental threats to this set. Threats to consider adding to the detection module would be for instance, trucks, motorcycles, ships and trains.

Improvement of existing detection methods and algorithms

Image processing was not the main focus of this thesis, so the methods and algorithms used to dynamically detect environmental were not perfect, far from it. Although the work done is sufficient when used on a controlled environment a more complex and efficient approach had to be done for a future release to the general public.

Connection to other Social Networks

The application eVision was developed with Facebook connection in mind but in the future connecting to other social networks should be considered. For example, connecting to the Twitter would give users the ability to tweet about locations cleaned in real time.

Let users add new geo-referenced threats

Maintaining a database with the location of environmental threats is not an easy task and a solution to this issue would be to let the users manage the information about geo-referenced threats. Users would be able to mark locations, which represent environmental threats, and share this data with the rest of eVision's users and possibly with authorities.

Analyse users' feedback

In the end of each questionnaire some users gave feedback of possible future improvements for the eVision application. A analyse about each suggestion would have to be done to assert the positive and negative consequences on the application goals, and the best ones would be considered for eVision's implementation.

Develop a version to distribute on Apple's Store

After the previous described future improvements were implemented, the application should be fine tuned to be ready for a release on the Apple's Store. This would allow reaching a larger number of people and consequently changing their behaviours or attitudes towards the environment.

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8 Annexes

8.1 Mann-Whitney U test results

Test Statistics^b

	As informações dadas acerca dos factores que afectam a qualidade do ar são credivéis.	No futuro terá em consideração as informações facultadas pelo Snowkin.	O Snowkin é uma personagem simpática.	O Snowkin é expressivo.	O Snowkin preocupa-se com o ambiente.	Enquanto utilizou a aplicação, sentiu-se bem quando o Snowkin elogiou a sua progressão.
Mann-Whitney U	49,500	47,500	49,000	43,000	41,500	44,000
Wilcoxon W	104,500	102,500	104,000	98,000	96,500	99,000
Z	-,042	-,201	-,094	-,656	-,801	-,542
Asymp. Sig. (2-tailed)	,966	,841	,925	,512	,423	,588
Exact Sig. [2*(1-tailed Sig.)]	,971 ^a	,853 ^a	,971 ^a	,631 ^a	,529 ^a	,684 ^a

a. Not corrected for ties.

b. Grouping Variable: Sexo do Participante

8.2 First Questionnaire

Questionário de Avaliação



Seguem-se uma série de questões acerca da sua experiência enquanto utilizador da aplicação *eVision*, relativamente às quais pretendemos que responda de forma sincera.

Lembre-se que todas as respostas são anónimas, confidenciais e servirão unicamente para avaliar a sua experiência com o *eVision*.

1. DADOS PESSOAIS

- 1.1. Sexo: Feminino Masculino
- 1.2. Idade: ____ anos
- 1.3. Habilitações: _____
- 1.4. Profissão: _____
- 1.5. E-mail (utilizado **unicamente** para aplicação de um questionário posterior)

Assinale com uma cruz (X) o número que melhor descreve a sua posição face às seguintes afirmações:

- 1.6. Considero-me uma pessoa **preocupada** com o ambiente.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

- 1.7. Considero-me uma pessoa **informada** acerca da sustentabilidade do Planeta.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

- 1.8. Os meus comportamentos reflectem uma atitude pró-ambiental (exemplo: evito usar viatura própria quando posso utilizar os transportes públicos).

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente



2. NOVAS TECNOLOGIAS

2.1. Está familiarizado com as novas tecnologias? Sim Não

2.2. Se sim, que tipo de tecnologias utiliza?

2.2.1. Computador

1	2	3	4	5
Diariamente	Semanalmente	Mensalmente	Raramente	Nunca

2.2.2. Consolas de Jogos

1	2	3	4	5
Diariamente	Semanalmente	Mensalmente	Raramente	Nunca

2.2.3. Telemóvel

1	2	3	4	5
Diariamente	Semanalmente	Mensalmente	Raramente	Nunca

2.2.4. Internet

1	2	3	4	5
Diariamente	Semanalmente	Mensalmente	Raramente	Nunca

2.2.5. Outra. Qual? _____

1	2	3	4	5
Diariamente	Semanalmente	Mensalmente	Raramente	Nunca



3. AVALIAÇÃO

Para cada uma das afirmações seguintes indique com uma cruz (X) o número da opção que mais se aproxima do seu ponto de vista.

3.1. ASPECTOS GERAIS

3.1.1. Gostei de utilizar o eVision.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

3.1.2. É fácil aprender a utilizar o eVision.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

3.1.3. É fácil utilizar o eVision, mesmo sem ajuda exterior.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

3.2. USABILIDADE E FACILIDADE DE USO

3.2.1. A aplicação requer poucos passos para executar cada tarefa.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

3.2.2. A aplicação respondeu rapidamente às diversas acções.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente



3.2.3. Classifique a facilidade de execução de cada funcionalidade:

- a) Utilizar a opção “Scanner” e observar a informação relativa ao meio envolvente.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

- b) Utilizar a opção “Scanner” e localizar um automóvel.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

- c) Utilizar a opção “Scanner” e localizar um avião.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

- d) Utilizar a opção “Scanner” e localizar uma infra-estrutura poluente (ex: fábrica).

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

- e) Utilizar a opção “Scanner” e limpar as várias ameaças detectadas.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

- f) Comprar objectos para o SnowKin.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

- g) Configurar a aparência do SnowKin.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade



h) Consultar estatísticas.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

i) Fazer *login* no Facebook e publicar as Estatísticas no Mural.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

j) Fazer *login* no Facebook e fazer *Like* à página da aplicação.

1	2	3	4	5
Muito Fácil	Fácil	Difícil	Muito Difícil	Não executei esta funcionalidade

4. APLICAÇÃO eVISION

O próximo grupo de questões refere-se à sua experiência enquanto utilizador do eVision. Por favor, responda de forma sincera às perguntas seguintes, escolhendo a opção que melhor corresponde à sua opinião.

4.1. De um modo geral, a sua opinião acerca da aplicação eVision é:

1	2	3	4	5
Excelente	Muito Boa	Boa	Razoável	Má

4.2. A utilização da aplicação eVision contribuiu para aumentar a minha consciencialização em relação aos problemas ambientais.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

4.5. Ao experimentar a aplicação, acedeu ao Facebook?

Sim

Não , porque _____



4.6. Escolha as emoções que melhor reflectem a sua experiência enquanto utilizador da eVision:

- | | | | |
|--------------------------------------|--|--|---------------------------------------|
| <input type="checkbox"/> Alegria | <input type="checkbox"/> Interesse | <input type="checkbox"/> Contentamento | <input type="checkbox"/> Stress |
| <input type="checkbox"/> Curiosidade | <input type="checkbox"/> Agressividade | <input type="checkbox"/> Empatia | <input type="checkbox"/> Cansaço |
| <input type="checkbox"/> Dúvida | <input type="checkbox"/> Decepção | <input type="checkbox"/> Frustração | <input type="checkbox"/> Prazer |
| <input type="checkbox"/> Entusiasmo | <input type="checkbox"/> Simpatia | <input type="checkbox"/> Tédio | <input type="checkbox"/> Divertimento |
| <input type="checkbox"/> Ansiedade | <input type="checkbox"/> Preguiça | <input type="checkbox"/> Gratificação | |

5. SNOWKIN

As próximas questões são acerca do Snowkin, a personagem virtual do eVision. Para cada afirmação, escolha a opção que melhor reflecte a sua opinião.

5.1. As informações dadas acerca dos factores que afectam a qualidade do ar são credíveis.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

5.2. No futuro terá em consideração as informações facultadas pelo Snowkin.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

5.3. A interacção com o Snowkin é:

1	2	3	4	5
Extremamente Agradável	Muito Agradável	Pouco Agradável	Muito Desagradável	Extremamente Desagradável

5.4. O Snowkin é uma personagem simpática.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente



5.5. O Snowkin é expressivo.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

5.6. O Snowkin preocupa-se com o ambiente.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

5.7. Enquanto utilizou a aplicação, sentiu-se bem quando o Snowkin elogiou a sua progressão.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

5.8. Durante a utilização do eVision, encarou o Snowkin como:

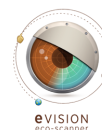
1	2	3	4	5
Um amigo	Um colega de equipa	Um professor ou orientador	Outro. Qual? _____	Não prestei atenção á personagem

6. CONTRIBUA COM A SUA SUGESTÃO / COMENTÁRIO / RECOMENDAÇÃO:

Obrigado pela sua participação.

8.3 Second Questionnaire

Questionário de Avaliação de Impacto



Seguem-se uma série de questões acerca da sua experiência enquanto utilizador da aplicação *eVision*, relativamente às quais pretendemos que responda de forma sincera.

Lembre-se que todas as respostas são anónimas, confidenciais e servirão unicamente para avaliar a sua experiência com o *eVision*.

Assinale com uma cruz (X) o número que melhor descreve a sua posição face às seguintes afirmações:

1. Porque motivo não utilizou o Facebook durante a sua experiência com o *eVision*?

1	2	3	4	5
Não possuo uma conta no Facebook	Não me senti à vontade para o fazer num dispositivo de outrém	Não senti necessidade	Outro motivo: _____	Eu utilizei o Facebook

2. A experiência com o *eVision* alertou-me para os problemas de sustentabilidade que o planeta atravessa.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

3. A experiência com o *eVision* teve, ou vai ter, peso nas minhas decisões (ex.: futura compra de um carro).

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

4. Depois de interagir com o Snowkin senti saudades da personagem.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

5. Os diálogos do Snowkin continuam relevantes para mim.

1	2	3	4	5
Concordo Totalmente	Concordo	Não concordo nem discordo	Discordo	Discordo Totalmente

1