

# Creating an Infographic to Explain a Scientific Concept

PATRÍCIA MIGUEL MARQUES PIRES

TRABALHO DE PROJETO SUBMETIDO COMO REQUISITO PARCIAL PARA  
OBTENÇÃO DO GRAU DE MESTRE EM AUDIOVISUAL E MULTIMÉDIA

Orientador:

Prof. Doutor Filipe Montargil  
Escola Superior de Comunicação Social

Coorientadora:

Prof.<sup>a</sup> Mestre Cátia Mendonça  
Escola Superior de Comunicação Social

Outubro de 2018



# ÍNDEX

---

## CONTENT INDEX

---

DECLARAÇÃO .....	III
RESUMO .....	IV
PALAVRAS-CHAVE .....	IV
ABSTRACT .....	V
KEYWORDS .....	V
ACKNOWLEDGEMENTS .....	VI
INTRODUCTION .....	1
1. INFOGRAPHICS.....	5
<b>1.1. THE EVOLUTION OF THE CONCEPT .....</b>	<b>5</b>
<b>1.2. APPROACHES TO INFOGRAPHICS .....</b>	<b>12</b>
<b>1.4. FEATURES OF INFOGRAPHICS .....</b>	<b>18</b>
<b>1.5. INFOGRAPHICS AS A COMMUNICATION TOOL .....</b>	<b>27</b>
2. CITIZEN OBSERVATORIES.....	34
<b>2.1. CONTEXTUALIZATION .....</b>	<b>34</b>
<b>2.2. DEFINITION .....</b>	<b>39</b>
<b>2.3. WHY IS IT IMPORTANT? .....</b>	<b>43</b>
3. THE PROJECT .....	46
<b>3.1. JUSTIFICATION OF THE IDEA .....</b>	<b>46</b>
<b>3.2. OBJECTIVES .....</b>	<b>47</b>
<b>3.3. METHODOLOGY .....</b>	<b>48</b>
<b>3.4. RESULTS.....</b>	<b>51</b>
<b>3.5. FINAL REMARKS.....</b>	<b>59</b>
REFERENCES .....	62
<b>Bibliography.....</b>	<b>62</b>
ANNEXES .....	68
<b>Annex I – Emails .....</b>	<b>68</b>
<b>Annex II – Surveys .....</b>	<b>73</b>

## ÍNDICE OF TABLES

---

Table 1. Behavioral Patterns and Interaction Techniques (an adaptation of Behrens, Rogers <i>et al</i> 's and Figueiras, elaborated by the author) .....	24
--	----

## ÍNDICE OF FIGURES

---

Figure 1. Illustration and annotations on the arms' bones, Leonardo da Vinci, 1510....	6
Figure 2. <i>Diagram of the Causes of Mortality in the Army in the East</i> , Florence Nightingale, 1858 .....	8
Figure 3. <i>Carte figurative des pertes successives en hommes de l'armée française dans la Campagne de Russie 1812-13</i> , Charles Joseph Minard, 1861 .....	10
Figure 4. Infographic "You vs John Paulson" (frontpage) .....	25
Figure 5. Infographic "You vs John Paulson" (output of the dynamic infographic) .....	25
Figure 6. Fundamental preattentive variables predominantly used in information design (Behrens, 2008) .....	29
Figure 7. <i>What Makes a Good Visualization?</i> (McCandless) .....	32
Figure 8. <i>The two dimensions and four types of innovation</i> (Norman & Verganti, 2014: 12) .....	37
Figure 9. Citizen Observatories' innovation process .....	38
Figure 10. Mockups of the mobile version: homepage, personas front page, example of a persona .....	51
Figure 11. Mockups of the mobile version: persona page, drop menu, projects page .....	52
Figure 12. Print screen of the desktop homepage .....	52
Figure 13. Projects page on the desktop version .....	53
Figure 14. Personas page on the desktop version .....	54
Figure 15. Survey on the desktop version of the infographics .....	73
Figure 16. Survey on the mobile version of the infographics .....	74

## DECLARAÇÃO

Declaro ser autora do presente trabalho de investigação, parte integrante das condições exigidas para a obtenção do grau de Mestre em Audiovisual e Multimédia. Declaro ainda ser este um trabalho original, nunca submetido (no seu todo ou em qualquer uma das suas partes) a uma instituição de ensino superior para obtenção de um grau académico ou de outra habilitação. Afirmo também que todas as citações aqui incluídas estão devidamente identificadas, e acrescento ter plena consciência de que o plágio poderá levar à anulação do estudo agora apresentado.

Lisboa,

---

Patrícia Pires

## RESUMO

### Palavras-chave

Infografia, Interação, Comunicação Visual, Observatórios de Cidadãos, Comissão Europeia

A comunicação visual tem estado presente na vida do ser humano já há vários séculos. Desde as pinturas rupestres até à inteligência artificial, a forma como o Homem comunica tem vindo a evoluir de acordo, também, com a evolução das tecnologias. Hoje em dia vivemos numa sociedade submetida constantemente a uma quantidade avassaladora de informação, ao ponto de já não ser possível ao ser humano absorvê-la toda. Neste sentido, são necessárias novas estratégias de comunicação, tornando a informação apelativa e destacando-a de tudo o resto. É aqui que a infografia adquire um papel extraordinário. Com recurso a imagens, a elementos de interação e a outros efeitos, a infografia consegue cativar o utilizador ao ponto de o envolver na própria informação. Tendo isto em mente, desenvolvemos uma infografia para explicar e disseminar um conceito científico, apoiado e financiado pela Comissão Europeia: os Observatórios de Cidadãos.

## ABSTRACT

### Keywords

Infographics, Interaction, Visual Communication, Citizen Observatories, European Commission

Visual communication has been present in human life for several centuries. From cave paintings to artificial intelligence, the way human beings communicate has evolved also according to the evolution of technologies. Today we live in a society constantly subjected to an overwhelming amount of information, to the point that it is no longer possible for the human being to absorb it all. Having that, new communication strategies are necessary, especially to make the information appealing and highlighting it from everything else. This is where the infographics take on an extraordinary role. Using images, interaction elements and other effects, infographics captivate the user to the point of engaging him in the information itself. With this in mind, we developed an infographic to explain and disseminate a scientific concept, supported and funded by the European Commission: Citizen Observatories.

## ACKNOWLEDGEMENTS

I would like to thank the teachers of this Master degree, especially for all the knowledge and techniques they taught my colleagues and I. Specifically, I would like to give a special thank you to my two supervisors, Professor Filipe Montargil and Professor Cátia Mendonça, for the tireless support and encouragement of becoming and doing the best I could.

To Professor Filipe Montargil, thank you for introducing me to the concept of Citizen Observatories and for the endless discussions we had throughout the development of this project. To Professor Cátia Mendonça, thank you for all the tips to improve the design and interactions of the project. Without the support of both of you this project would not be the same.

To my closest friends, thank you for supporting me and this crazy idea of doing a second master. Believing in me from the very beginning was the biggest motivation you could have given me.

To my mother and brother, thank you for always being there and for supporting me no matter what. I am who I am today because of you, and I know dad would be proud, just as I know you are as well.

Last but not the least, thank you to my partner in crime: Pedro. For your unconditional help, motivation, support and love, thank you.

## INTRODUCTION

*Tell me and I'll forget; show me and I may remember; involve me and I'll understand*  
Chinese proverb

This Chinese proverb was first used by Xun Kuang, a Chinese Confucian philosopher that lived from 312-230 BC. It is originated in the book of Xunzi, one of the main contributions to the Hundred Schools of Thought (Schwartz, 1985). Xun Kuang was a teacher who believed knowledge would be much more effective when put into practice (Goldin, 2018).

Nowadays we live in a time where we get so overwhelmed with information that it turns out to be very difficult to keep up with everything. Making information visually appealing is one strategy to catch viewers' attention but making them engage with information may as well be another powerful way. As we will see, people who engage with information will retain it much longer than others who don't.

Infographics have been used for a long time now, in different contexts and for different purposes, to communicate about a given topic. The one area where this has been used probably the most is journalism. The simplicity of a lot of infographics allows journalists to communicate more easily about complicated themes, allowing anyone with or without knowledge to understand those themes.

When looking for academic works on infographics, most of what we can find is on the application of infographics to journalism, and most of them are thesis and theoretical works. This gave me an opportunity to think of a different work to present as my final one in this master's degree.

I knew from the beginning that I wanted to develop an infographic project. However, if I wanted to pursue it, I needed to have a theme to work on. That was when I was introduced to the concept of Citizen Observatories (CO). I already knew what Citizen Science was, but I did not know what CO were. Besides that, it was not easy for me to understand how it worked. My academic background is in life sciences, so I thought that if I was having trouble understanding what CO were, people without any knowledge could face the same problem and lose interest to it. As we will see, a key factor for the success of a CO project is the mass volunteer participation from citizens, so having people not only not knowing what it is but also having no interest in knowing about it is halfway for these projects to not having the expected success.

As soon as I understood what CO were, how they worked and how important they are, I knew this master final work would be an amazing opportunity to fill two gaps: the lack of projects on infographics (not related to journalism) in the academic world, and the lack of knowledge from the general population on Citizen Observatories. These were the main reasons why I wanted to do this project in the first place. However, personal and professional reasons joined in, as I will further explain on this document.

This project consists of two main parts: this document and a functional online infographic. In this document you will find the theory that supports my work as well as the description of the methodology it was used to develop the web infographic.

This document is organised in three chapters. The first is entirely dedicated to the main theme of this thesis: Infographics. We begin by looking at the origins of infographics and how this concept evolved over the years. This is important to understand the different needs and purposes this tool has satisfied.

From journalism to design, infographics have been used in such different contexts that we found it hard to get a single definition for it. Naturally, infographics will have specific features for specific purposes. In this first chapter, we also discuss the different types of infographics, its purposes and the similarities that may or may not exist between all of them. Last but not least, we end the chapter by explaining how infographics can be a powerful communication tool and how it can make a difference in a communication strategy plan.

The second chapter is dedicated to the theme we will approach on the infographics: Citizen Observatories. This is a quite new concept in Citizen Science that, in order to work and be successful, needs mass volunteer participation from citizens. The European Commission has already invested in four CO projects, which ended by 2016. In 2017, the EU invested in four more projects that will end by 2019. In this chapter we explore this concept, its origins and how it can benefit from a better communication strategy.

And this leads us to the final chapter. This is where I explain in detail why I wanted to do a project as a final work for this master, how this idea came to life and how I developed the infographics from the start to the very end. The methodology will be described and the final mock-ups will be presented in this chapter.

With this project I also wanted to practice and improve my skills in design and code, so it was only fair that I would go beyond mock-ups and develop the infographic for the web. We decided to extend the project to the point of having something final to work and to present to the community: a functional online infographic both in a desktop and a mobile version.

I strongly believe in the quote with which I began this introduction. I believe that practice leads to a deeper knowledge, so, as a master student, I wanted to take the most out of this degree and bind together

the knowledge I acquired during this degree with my own personal interests and with the opportunity to improve my skills in design and code. With it I also wanted to bring something new to the academy, regarding infographics.

Furthermore, I was hoping I could do something that could be used (and shared) by anyone to learn about this new concept in a fun and practical way. I know now how important Citizen Observatories are, both for society and for the scientific community, so I hope that with this project I can somehow contribute to the success of this concept, through an efficient communication resource.

## 1. INFOGRAPHICS

This chapter aims to offer an overview of the main subject of this project: infographics. We will analyse its origin and definition and explore the reasons why this is such a powerful tool for communication in science and, also, in our day-to-day activity. And as this is a project on multimedia and interactive infographics, we will also overview some good practices to create infographics.

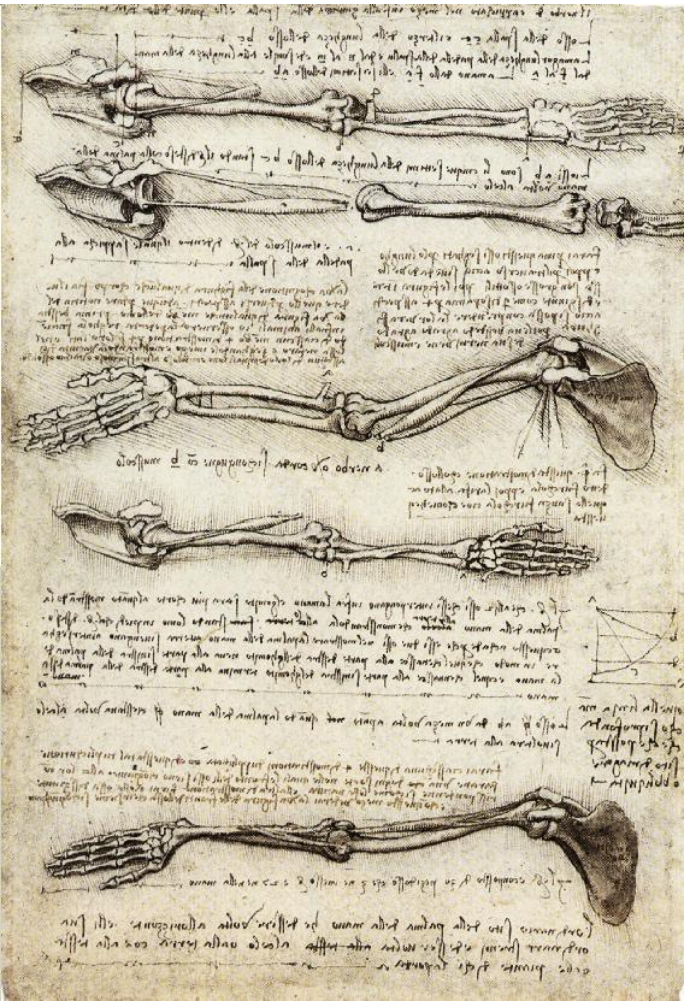
### 1.1. THE EVOLUTION OF THE CONCEPT

For about 32.000 years that the human being has been drawing and it is thought that cave men were the first to communicate through pictures in cave walls, where they drew everyday life elements such as animals, plants and even other people (Giovanninni, 1987; de Pablos, 1999; Cairo, 2005).

As human beings evolved, so have its capabilities of (re)presenting information. From geography to science and music, there are several examples on how the representation of data evolved until today. The oldest known map is dated 3,800 BC. It is engraved on a clay tablet and represents a region of Northern Mesopotamia (Beniger & Robyn, 1978). In 3,200 BC the Egyptian surveyors used coordinate systems to locate points in space (*idem*). It was also during the year 3,000 BC that Egyptians created their own system of communication, using symbols and icons, called hieroglyph. It was widely used, for centuries, to tell about everyday-life situations. Musical notation surfaced around 700 BC with the usage of about 300 symbols based on contemporary alphabet (*idem*).

However, probably the most outstanding breakthroughs of representing information occurred in the scientific world. Even though

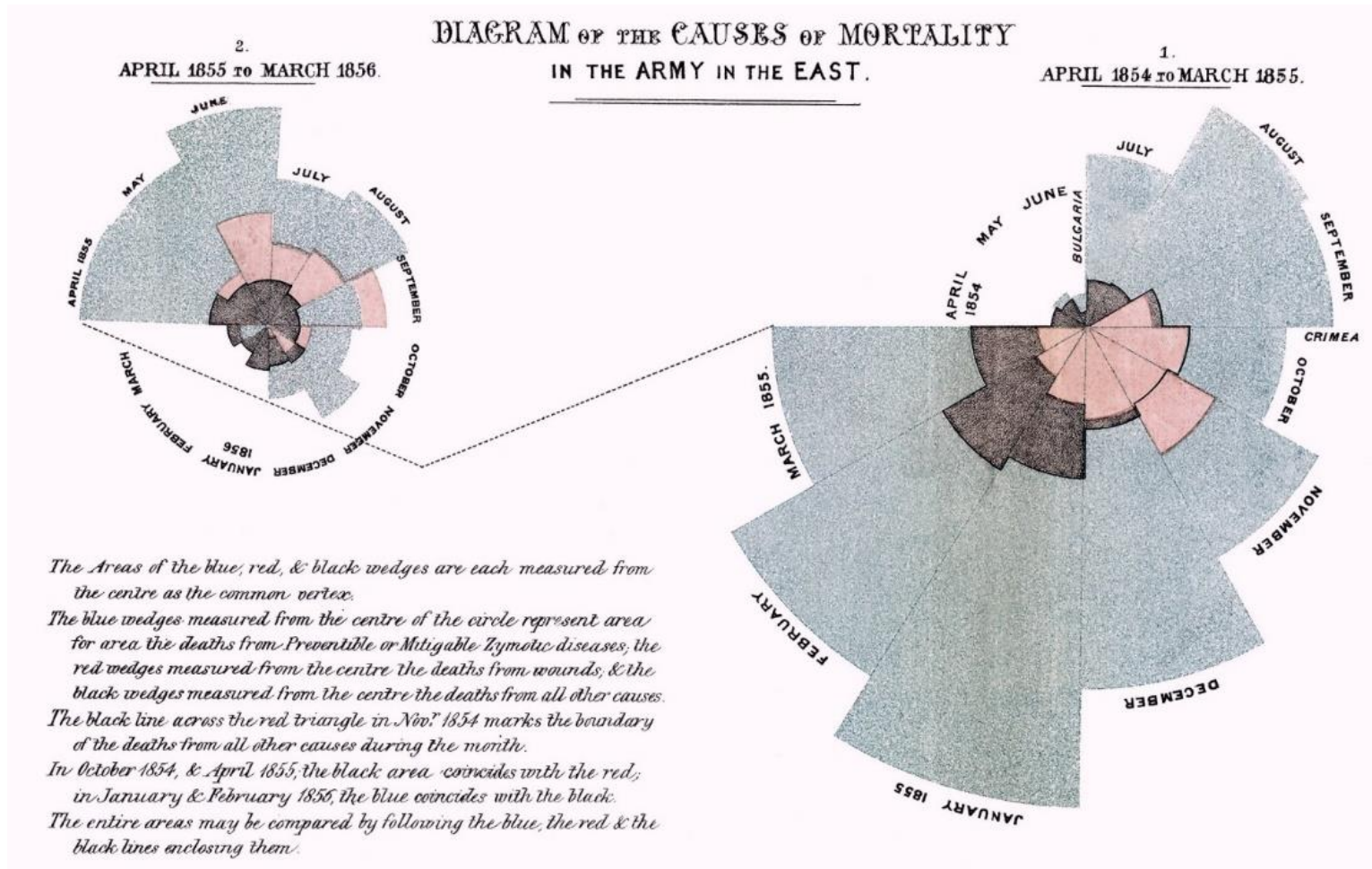
there are records of earlier milestones in quantitative graphs, the first proto-bar graph for theoretical function was done by Nicole Oresme, a French mathematician, in the year of 1350 (Beniger & Robyn, 1978; Smiciklas, 2012). He created these graphs so that he was able to explain how to measure a moving object (Smiciklas, 2012). To Oresme followed Leonard da Vinci (1500, he combined written instructions with illustrations to create comprehensive and accurate illustrations on human and animal anatomy and his own mechanical inventions), René Descartes (who established the relationship between graphed line and equation, 1637), William Playfair (who invented the bar chart, 1786, the pie chart and the circle graph, 1801), and so on (*idem*).



**Figure 1.** Illustration and annotations on the arms' bones, Leonardo da Vinci, 1510

The representation of data became more complex over time, especially when combining several different variables and data into only one illustration. In 1858, nurse Florence Nightingale created the *Diagram of the Causes of Mortality in the Army in the East* (

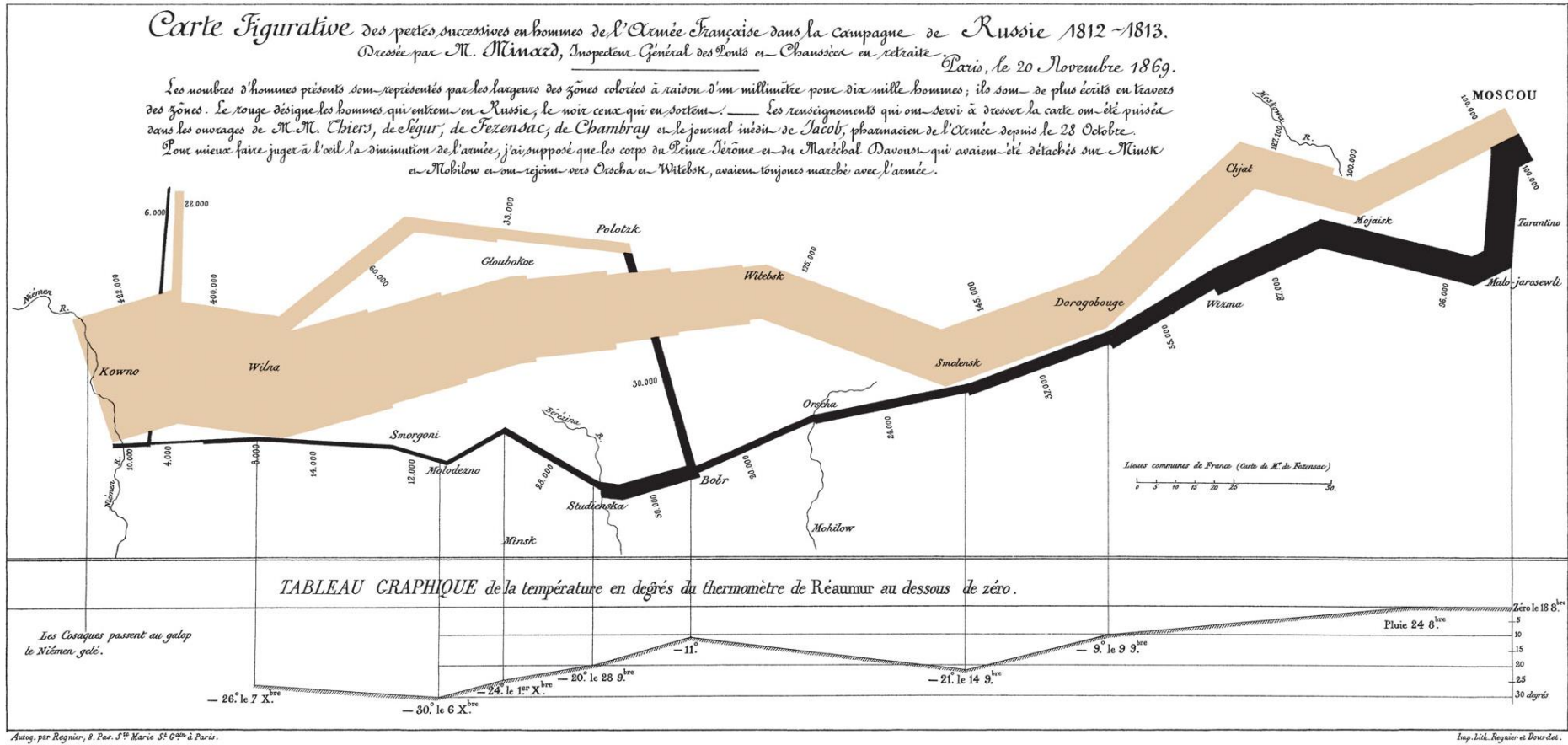
Figure 2), where she illustrated the causes of the British Army's mortality during the Crimean War (Lankow *et al.*, 2012). This diagram was published in the report *Notes on Matters Affecting the Health, Efficiency and Hospitality Administration of the British Army* and presented to the Parliament. It is said that Nightingale used this illustration to convince Queen Victoria to improve conditions in military hospitals (Smiciklas, 2012).



**Figure 2.** *Diagram of the Causes of Mortality in the Army in the East*, Florence Nightingale, 1858

A few years later, in 1861, French engineer Charles Joseph Minard designed a diagram (

Figure 3), using flow charts to demonstrate the “successive losses of men of the French army during the French invasion of Russia in 1812” (Tufte, 2006: 123). This seemingly complex diagram is no more than a combination of data that depicts the losses suffered in Napoleon’s army during the campaign of the invasion of Russia, in 1812. The map represents the size of the army during the conflict, its location over time, the direction of the army’s movement and the temperatures registered on various dates during the retreat from Moscow (Tufte, 2001). Tufte describes this infographic saying that “vivid historical content and brilliant design combine to make this one of the best statistical graphics ever” (Tufte, 2006: 122). This infographic ended up being the basis of Tufte’s explanation of his six essential principles for the development of a good analytical design.



**Figure 3.** Carte figurative des pertes successives en hommes de l'armée française dans la Campagne de Russie 1812-13, Charles Joseph Minard, 1861

These types of diagrams began to be popular for editorial use during the decade of 1930 (Lankow *et al.*, 2012), but it wasn't until the Gulf War, in the early 90's, that the revolution of infographics really began (Cairo, 2008). It was very difficult, during this specific conflict, for journalists to share information on what was happening in the war zone. The television coverage was poor, and journalists had little to no access to some of the most important and central regions of the conflict (Cairo, 2008; Rodrigues, 2013). Facing this situation, journalists had to rely on illustrations to share information on the war, especially maps and explanations of the armoury and war strategies (de Pablos, 1999; Cairo, 2008). These infographics were published in the journal USA Today and, from that day on, the journal invested in producing more and better infographics, constantly adapting to the new computer and software resources, and hiring a good team of infographers (Cairo, 2008).

Even though the usage of illustrations in the war situation was a necessity to inform, it was not enough for infographics to stand out. In fact, the breakthrough of these schematics and illustrations in the newspapers was only possible because of the emergence of the first computers and graphical softwares (Schmitt, 2006; Silva, 2010). According to Sancho (2001), the new digital era that appeared in the late 1980's and beginning of the 1990's opened a new phase for infographics, which took advantage of computers and new, sophisticated software for image edition. Basically, informatisation not only facilitated the production of infographics, it also made it much easier to be distributed online.

The evolution of those technologies also allowed infographics to develop into something more complex, adaptable to the new demands of an increasingly digital society. Rodrigues (2013) distinguishes three main development stages of infographics:

- Linear infographics – the first web infographics, in a sequential static form, which worked better on printed journals and could be compared to storyboards or even slideshows of images with little visual narrative;
- Multimedia infographics – introduction of motion pictures, sound recording, illustrations, videos and other interactive materials. Here multimedia software platform Flash is used to create pictures with movement and infographics are interactive;
- Database infographics – the current stage of infographics on the web. This is characterized by the introduction of databases and a greater interactivity on the infographics, exploring Web 2.0 apps like Google Maps.

As we can see, infographics have a long history and have profited with the digital era. Nowadays we are constantly overwhelmed with new information in a lot of different formats. And while this is an opportunity for most companies to share information, it is also a big challenge for them to stand out and be able to get the consumers/users' attention. We will see why infographics are so important and how they make a difference in sharing information in this digital era.

## 1.2. APPROACHES TO INFOGRAPHICS

We have seen that infographics have evolved from simple cave drawings to diagrams, data-maps and then into more complex illustrations of wars and military strategies. Tufte was a pioneer studying graphical displays and, in his book, *The Visual Display of Quantitative Information*, he listed the conditions for what graphical displays should accomplish (2001:13):

- Show data;
- Induce the viewer to think about the substance rather than methodology;
- Avoid the distortion of significance of the data;
- Show many numbers in a small space;
- Make large data sets coherent;
- Encourage comparisons to different data sets;
- Reveal data from a broad view to a detailed one;
- Serve a purpose: description, exploration, tabulation or decoration;
- Be closely integrated with both the statistical and verbal descriptions of data set.

A few years later, and inspired by Minard's data-map, he improved these conditions into six "fundamental principles for analytical design" (Tufte, 2006).

The first principle is comparison: "Whether we are evaluating changes over space or time, searching big data bases (...), the essential point is to make intelligent and appropriate comparisons. Thus, visual displays, if they are to assist thinking, should show comparisons" (Tufte, 2006: 127). Only then can we spot contrasts and differences between variables.

The second principle is causality, mechanism, structure and explanation. In Minard's map there is no explicit explanation for the causes of death for the Napoleon army. However, the presence of the temperature graph during the withdrawal may be presented as a cause for the deaths: "simply collecting data may provoke thoughts about cause and effect: measurements are inherently comparative, and comparisons promptly lead to reasoning about various sources of differences and variability" (*idem*: 128).

A third principle is multivariate analysis. The six variables shown in Minard's map explain, all together, the war of 1812: "reasoning about evidence should not be stuck in 2 dimensions, for the world we seek to understand is profoundly multivariate. Strategies of design should make multivariateness routine, nothing out of the ordinary" (*idem*: 130). In fact, be it the biological, physical, human or even imaginary worlds we look for to understand, they are inevitably multivariate.

A fourth principle is the integration of evidence. The map's author gathers different types of information to describe the troop movements and the consequences of the war: "a paragraph of words, a map with narrating flow-lines, and a statistical graphic dangling from the map" (*idem: ibidem*). According to Tufte, words, numbers, pictures, diagrams, graphics, line-art, grids and measurement scales belong together, especially in excellent analytical graphs: "a deeper understanding of human behaviour may well result from integrating a diversity of evidence, whatever it takes to explain something. Like good information displays, explanatory investigations, if they are to be honest and genuine, must seek out and present all relevant evidence regardless of mode" (*idem*: 131).

The fifth principle proposed by Tufte is documentation. Both the quality and the integrity of the authors and their data sources will influence the credibility of a presentation of an evidence: "documentation is an essential mechanism of quality control for displays of evidence. Thus, authors must be named, sponsors revealed, their interests and agendas unveiled, sources described, scales labelled, details enumerated" (*idem*: 132).

According to the sixth principle, content counts most of all. Even though Minard's map never mentions the word "Napoleon", its content focuses on the human costs and not on the human survivors, which

reveals a good knowledge and caring from the author about the substance.

With these six principles, Tufte implies that graphics are meant to reveal data and that they can be more precise than “conventional statistical computations”. For this author, if all graphic elements of a given design do not communicate a specific information, then they should be omitted.

The principles enunciated by Tufte are very important for any graphical designer or infographer, however these principles are not enough, for example, for the journalists’ purposes. Tufte has a scientific approach to information visualization, where graphics and diagrams should speak for themselves. However, there are other authors that emphasize aesthetics instead. Nigel Holmes is one of those authors that stands on the opposite end of Tufte’s. He supports the use of illustration and decoration to make information design more appealing to the viewer.

Both approaches (scientific and aesthetic) are valid and should be used accordingly to the objective of the design. On one hand, people with technical backgrounds such as statistics, computer scientists or engineers will naturally use the scientific approach to infographics. In this approach, information is shown in the most neutral way, encouraging the viewers to analyse and explore the data. On the other hand, designers and journalists (Cairo, 2013) will give a major importance to aesthetics. In this approach, information is embellished, and most times even organized in such a way that a narrative is built around it, easily catching the viewers’ attention to the message.

Having two alternatives does not mean that a given professional must stand by only one approach. See, for example, the illustrations on scientific papers. Whenever necessary, scientists must include in their papers graphics with results, but also illustrations that show the

procedures and methodologies used during the research. It all comes down to the goal that the communicator wants to achieve.

### 1.3. DEFINITION

Because infographics were mainly popularized in the journalistic context, (i) most definitions emphasize the journalistic use and (ii) there is no consensus on the best word(s) to use to name “infographics”: data visualization, graphic information, information visualization and visual storytelling.

Just like technology has evolved through times, so have infographics (as we have seen from the main stages of infographics). Depending on the format, on the support and on the objective of the communication, different perspectives on what infographics are will emerge. For some people it will be a simple graph. For other people, it will be a set of elements that combine to inform a given message. And for others, it will be the story and narrative that those elements will tell all together.

For de Pablos (1999), for example, infographic is the use of the binomial image and text (I+T) in any communication. For this author, infographics always existed, however they must be distinguished from the draws of the cave men because these had no support in a real medium of communication, as today’s have in a newspaper, for example. Furthermore, to de Pablos, “infographics” is not the same as “graphic information” because journalism has always included graphics, diagrams, maps, illustrations and images in their articles, and infographics allow to explain, through images and small texts, details that would be unnoticed otherwise. This made the author distinguish general infographics from journalistic infographics, a product of info journalism.

Alberto Cairo uses “information visualization” as a synonym to “infographics” and defines it as “any information presented as a diagram that shows the relationship between all parts of a system” (2008: 21), used with communicational purposes. In concordance with this definition of Cairo is also the definition of the Oxford Dictionary, which indicates that an infographic is “a visual representation of information or data, e.g. as a chart or diagram”<sup>1</sup>. However, for Figueiras (2014), “information visualization is much more than the visual representation of data. It is rather the process of dissecting raw data, which by itself has little meaning and presenting it in a way that it is no longer complex” (Figueiras, 2014: 19).

Other terms have also appeared in some “how-to” books such as *Infographics: The Power of Visual Storytelling* by Lankow *et al.* (2012), or *The Power of Visual Storytelling: How to Use Visuals, Videos, and Social Media to Market Your Brand* by Walter & Gioglio (2014). On the former, the authors distinguish data visualization – a visual representation of data or the practice of visualizing data, using pie charts, bar graphs, line charts, etc. (Lankow *et al.*, 2012) – from infographic – an abbreviation of information graphics – from editorial infographic – “an infographic for use in print, an online publication or a blog” (Lankow *et al.*, 2012). On the latter, Walter and Gioglio define infographic as visual representations of information, bringing together the data and visuals to tell a story; but they also introduce the concept of visual storytelling: “defined as the use of images, videos, infographics, presentations, and other visuals on social media platforms to craft a graphical story around key brand values and offerings” (Walter & Gioglio, 2014).

Having all these different definitions to the same word and having all these terms can be confusing, especially when there is scarce academic

---

<sup>1</sup> <https://en.oxforddictionaries.com/definition/infographic>

work on the subject. As we can see, all these different authors stand by their own definitions of infographics, some of them even giving it a different word. However, we can also see that they all agree in one thing: infographics are a little more than the visual representation of information.

It is the dissection of raw data and information into something simpler and easier to understand for the regular public, like diagrams, charts, schematics, images and little pieces of text. For authors like Tufte, de Pablos, Figueiras and even Cairo (for whom infographics and information visualization are the same), this is what infographics are all about, as long as the connections between all data and information can be perceived by anyone who reads and interprets the infographics. Authors like Lankow and Walter and Gioglio go a little further, introducing a narrative component to the infographics. The latter authors stand for a more editorial/aesthetic approach of infographics while the former stand for a more scientific approach.

This project aims to build an infographic that may be published in a specific website and shared online. And for this reason, during this whole project we will be using infographics with an editorial/aesthetics approach.

#### 1.4. FEATURES OF INFOGRAPHICS

We have seen before in this project that Tufte was a pioneer in identifying the main features for a good graphic design and, later on, he even enunciated the six fundamental principles for analytical design (2006). And even though these principles remain true to these days and are used by many graphic designers, they are also mainly important in infographics that stand in the scientific approach. Regarding the

aesthetics/editorial approach, we have also seen that having a good narrative is also a must-have feature for any infographic.

A common thing among all infographics is their structure: a good infographic should have a title, a small introductory description of the theme, the illustration itself (with subtitles, preferably), conclusions (if necessary) and the sources. These items provide guidance on how to read the infographic, contextualizing the reader on the theme. The sources are relevant to give credibility to the information.

Infographics may have other features that make them more appealing and engaging, especially when used in an editorial/aesthetics approach. Animations, for example, can do such a good work catching the users' attention. Buttons, search engines, actions giving the opportunity for the user to change, insert, select, choose, reveal or hide information, they can also do such work. These features allow the user to interact with the infographics but also to engage with it, at the same time they give the user an opportunity to explore more freely the data at his/her own pace.

Those interactive features are a result of the evolution of infographics. Linear infographics (mostly static images for print purposes) and some multimedia infographics (animations and videos) only require the viewer to see and absorb the information that is being presented to him/her. This is a linear (or one-way) form of communication and the user is passive towards it. Nowadays, database infographics and some multimedia infographics allow the user to be active towards it, by clicking, inserting data, changing the dynamics of the infographics, and so on.

To understand what interaction and interactivity are, is to understand how these features are used in infographics to make them more engaging and a more powerful communication tool (Figueiras, 2015). Interaction is defined by Wagner as "reciprocal events requiring two objects and two actions" (1997: 20) that happen when "objects and events mutually influence one another" (*idem: ibidem*). Interactivity is defined as the

technological capability for making connections from one point to another in real time. This author employs “interactivity” in a context of distance learning experience and “interaction” as the behaviour from one individual or group of individuals that influence one another (*idem*).

Interaction, therefore, requires agents between which the action takes place. In this context of distance learning, the actions can take place between (i) learner and instructor, (ii) learners and (iii) learners and the medium they are learning from (*idem*). However, they can be extended to all contexts: (i) user and designer, (ii) users and (iii) users and the viewing medium (web page, print page).

Interactions have several outcomes, amongst which are changing learners/users and move them towards an action that allows them to achieve a certain goal (*idem*). In fact, Wagner classifies interactions into 12 different types, according to their objectives, all in the learning context, even though they can also be applied to any other context:

- interaction to increase participation (related with the individual willingness to engage in the learning process);
- to develop communication (ability to exchange information without the fear of being misjudged);
- to receive feedback (feedback is defined here as “any information that allows learners to judge the quality of their performance” (*idem*: 23));
- to enhance elaboration and retention (ability to find alternative examples to explain one idea, making new information more meaningful);
- to support learner control/self-regulation (capability of staying focused on a task and recognizing when it needs more or when it is a completed task);

- to increase motivation (interaction here in the sense that it allows the learner to find the answers to his/her questions or to clarify subjects);
  - for negotiation of understanding (ability to use the learner's understanding to make decisions);
    - for team building (ensures that individuals support the objectives of the group);
    - for discovery (when people argue with each other in order to reach a conclusion);
    - for exploration (this leads to the interaction for discovery as it helps define parameters that will differentiate new and old knowledge);
      - of clarification of understanding (ability to know if what one person is saying is what she intended to say in the first place);
      - for closure (ability to know when the learning process is over).

A good infographic that uses interaction features may seek for more than just one of those objectives. An infographic may (and should) have interaction features to increase participation, to enhance elaboration and retention and to increase motivation, at the same time it urges the user, who seeks for clarification of understanding, to discover and explore the contents of the infographic.

To achieve those goals, interaction makes use of some features like buttons, filling fields, search boxes, etc. These features may be organized in different styles (Rogers *et al.*, 2011), categories (Behrens, 2008) and techniques (Figueiras, 2015).

Rogers, Sharp and Preece (2011) have a broader view of interaction and define four different styles of interaction:

- Instruction: the simplest type of interaction in which the user tells the infographics to do something, whether through buttons, commands or clicking on the mouse;

- Conversation: a “futuristic” style with which the user will be able to change the parameters of the infographics by speaking to the phone instead of typing;

- Manipulation: “we allow manipulation when we let readers change the structure and appearance of what is presented to them, so they can achieve certain goals” (Cairo, 2013). An example of this could be the IKEA software that allows the user to build their own room with the types of furniture they choose;

- Exploration: the tool that allows the user to navigate inside graphics, especially used in 3D models.

Behrens is more specific and introduced a collection of design patterns for interactive information visualization that “provides a fundamental overview of tools and methods for data visualization in different contexts” (2008: 36). Each of those patterns have a fixed position within a hierarchical order structure that allows the user to select the subset that fits best his/her specific needs (*idem*).

On the top level of the hierarchy are display patterns, which describe “how information is depicted in the context of certain data material and usage purposes” and includes correlations, proportions, hierarchies and networks, for example; following display patterns we can find behavior patterns that deal with the features that provide dynamism to the interactive infographics (i.e.: functionalities that allow to navigate a map or filter data on a chart); and finally we have interaction patterns that includes the essential elements of the interface that let the user give inputs to the system and then interact with the infographics.

On one hand, on the behavioral pattern, the user can navigate, filter, arrange, explore and transition the data. On the other hand, the interaction patterns allow the user to interact with an infographic in the Boolean language: “either he selects an element, or he doesn’t” (*idem*: 171); allow the user to explore large data based on intervals; and to navigate within a spatial display. Within these patterns, we can find interaction techniques such as those proposed by Figueiras (2015): filtering and selecting, abstract/elaborating, overview and exploring, connect/relating, reconfiguring, encoding, history, extraction of figures, participation/collaboration and gamification.

We summarized the patterns and their techniques on Table 1.

<b>Display Patterns</b>	<b>Correlations</b>	Scatterplot
		Bubble chart
	<b>Continuous Quantities</b>	Simple line chart
		Multiset line chart
		Stacked Area Chart
		Sparklines
	<b>Discrete Quantities</b>	Simple bar chart
		Multiset bar chart
		Dot matrix
	<b>Proportions</b>	Simple pie chart
		Ring chart
	<b>Flows</b>	Sankey diagram
		Thread arcs
	<b>Hierarchies</b>	Tree diagram
		Tree map
<b>Networks</b>	Tree diagram	
	Relation circle	
	Pearl necklet	
<b>Space</b>	Topographic map	
	Thematic map	
<b>Behavioral Patterns</b>	<b>Navigation</b>	Simple zoom
		Local zoom

		Panning
		TimeLine
		Linked Multiples
		Overview Plus Detail
	<b>Filtering</b>	Layering
		Active Objects
		Boundary Filter
		Facet Browsing
	<b>Arrangement</b>	Dynamic Query
		Selective Arrangement
		Sortable Columns
		Custom Dimensions
	<b>Exploration</b>	Isolated Comparison
		Detail on Demand
<b>Transition</b>	DataTip	
	Animated Transition	
<b>Interaction Patterns</b>	<b>Selecting</b>	Radio Button
		Check Box
		Dropdown Menu
	<b>Linear Adjustments</b>	Single Slider
		Double Slider
	<b>Spatial Navigation</b>	Drag and Drop
Selection Mask		

**Table 1.** Behavioral Patterns and Interaction Techniques (an adaptation of Behrens, Rogers *et al.*'s and Figueiras, elaborated by the author)

Even though this table is an adaptation of Behrens' classification, the styles of Rogers *et al.* and the taxonomy proposed by Figueiras are also included. For example, Behrens navigation and arrangement includes Figueiras filtering, selection, overview and exploring, which are all included in the instruction style of Rogers *et al.*.

Even though the classification of Behrens is very accurate, it does not seem to include an option of data input. This is a recent feature, result of the emergence of data-based infographics, which allow the user to insert a given information, and the infographics will adjust accordingly. For

example, the infographic called “You vs John Paulson”<sup>2</sup> (online) requests the user to introduce his/her salary and calculates how long it takes John Paulson, a super-trader, to earn his/her salary. The results are then shown in a dynamic infographic (Figure 4 and Figure 5).

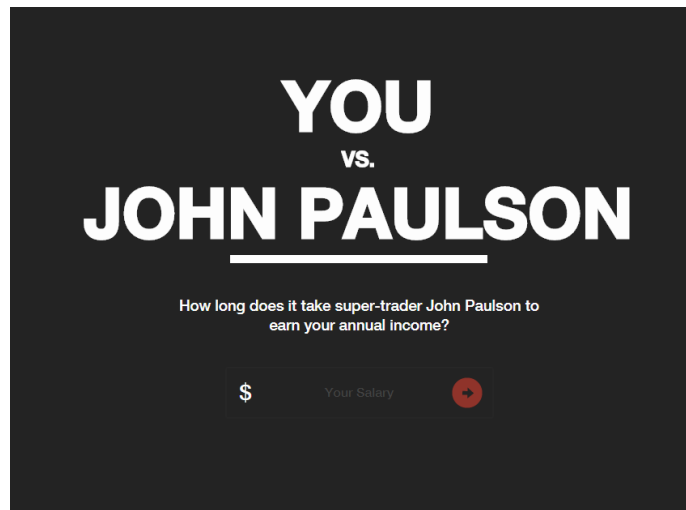


Figure 4. Infographic “You vs John Paulson” (front page)

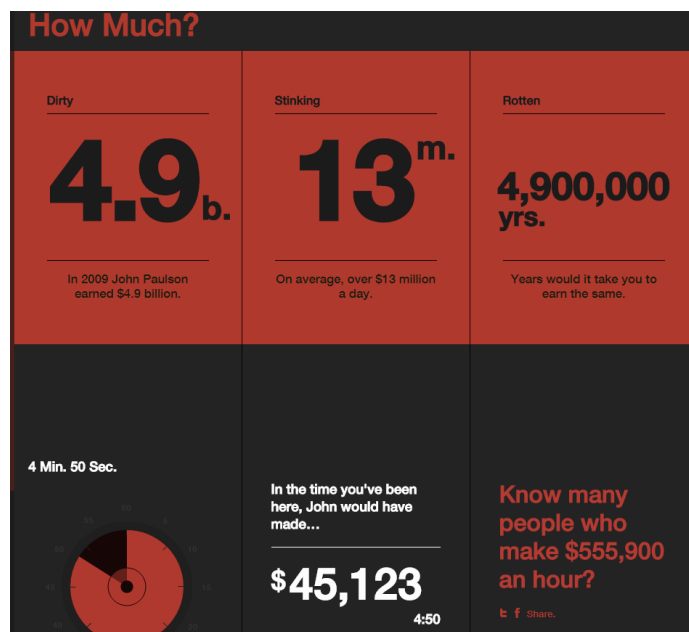


Figure 5. Infographic “You vs John Paulson” (output of the dynamic infographic)

<sup>2</sup> <https://mahifx.com/mfxtrade/john-paulson/>

Other features are slowly emerging, such as what Rogers *et al.* call *conversation* and Figueiras calls *participation and collaboration*.

The former is simply a different way for the user to give information/data to the infographics, however, the latter goes even further, by allowing anyone to contribute to the visualization, interpretation or understanding and sharing of their own insights. This concept of participation and collaboration rose from blogs and forums and is now being applied to visualization. Take as an example the *Home and Away: Iraq and Afghanistan War Casualties*<sup>3</sup> infographics. This is a web-based visualization by CNN that maps the fallen soldiers in Afghanistan and Iraq wars. It allows the users to add information (memoirs, videos, photos) about each soldier on their profile visualization.

Interactivity has been used in information visualization mostly to make data more engaging or playful. It gives infographics, in this case, a more engaging way to absorb knowledge and to learn. If an infographic has interactivity displays and allows interaction with the user, it becomes an even more powerful tool than it has been. Just like Figueiras (2015) claims, employing interactive techniques gives “users the ability to properly explore the data and find appropriate answers to their questions” (*idem*: 140), making visualization an exploratory activity rather than an explanatory one. If an infographic really takes advantage of this technique, it should not be considered a linear form of communication, but a non-linear (or two-way) one.

Considering the definitions of both interactivity and interaction, we propose a classification of infographics by type of interaction:

---

<sup>3</sup> <http://edition.cnn.com/SPECIALS/war.casualties/index.html>

- Linear infographics: infographics for editorial use or for web publication that includes static photographs or illustrations, accompanied or not by small parts of texts. All the information the user needs to understand the communication is available, so it is expected that the user only observes the information and will be able to take conclusions;
- Non-linear infographics: infographics for the web that have interactivity displays and allow interaction between the presented information and the user. This type of infographics allows the user to explore it and find new information, through several different types of mechanisms that give the user a feedback on his/her actions on the infographics. It can be:
  - o Explorative infographics: which include all the simple actions like clicking on buttons, scrolling the page and all navigation settings such as zooms, panning's and arrangements;
  - o Limited Manipulative infographics: infographics that change the information according to an existing database. In these infographics the user is allowed to filter information (either by layering, check boxing or adjusting with sliders) and to select types or categories of pre-existing categories;
  - o Unlimited Manipulative Infographics: infographics that allow the user to introduce any values and that show information accordingly.

#### 1.5. INFOGRAPHICS AS A COMMUNICATION TOOL

We live in a society that has been transformed by the Information Age, which made it possible to produce and share large amounts of information much faster than ever before. However, this production is so large that human beings are now living overwhelmed with information

(Figueiras, 2013). "As a result, it is increasingly difficult to get people's attention, since they're constantly bombarded with various stimuli throughout the day..." (Lankow, *et al.*, 2012: 40). Considering this situation, making information look appealing "makes it easier to understand, to scheme, to recognize patterns and to make inferences upon the data" (Figueiras, 2013: 351), which is why we believe it is so important to use infographics. Furthermore, the growing use of ICT and social media made it easier to share contents on Internet (*idem*).

As Ware points out:

"(...) some visual languages are easier to "read" than others. But why? Perhaps it is simply that we have more experience with the kind of pictorial image shown in the cave painting and less with the mathematical notation. Perhaps the concepts expressed in the cave painting are more familiar than those in the equation." (2004: 6).

There are a few reasons for why humans find it easier to process visual information, with biology being the most important.

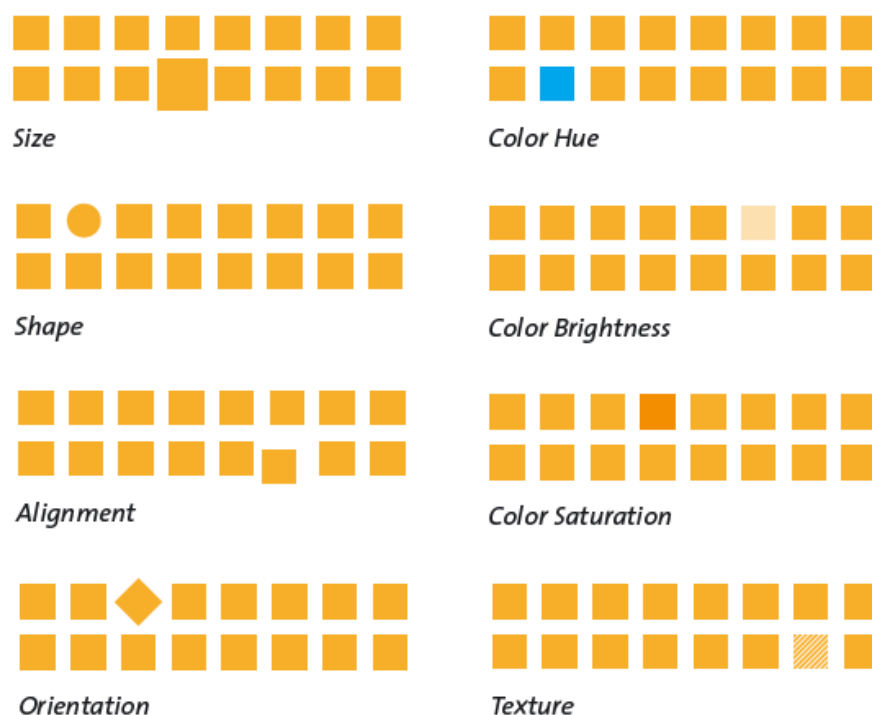
The human brain processes visual information much faster than any other type of information because half of it is dedicated to visual activities (Sheth *et al.*, 1996). When reading a text, the brain interprets letters as symbols, which means that to read something, the brain needs to decode those symbols and give them a meaning. Therefore, it is physically easier for the brain to read pictures instead of words.

Besides, the human brain filters most of the sensory information received, however every new (or unusual) information that is perceived catches the brain's attention (Wolfe, 2001, in Smiciklas, 2012). This is related with the principles of Gestalt psychology, formulated in 1980's by cognitive scientists. They described human perception of visual elements

on a low cognitive level in relation to visual qualities of a given object (Julesz, 1981 in Behrens, 2008).

These visual elements, or attributes, of graphic objects are noticed unconsciously, or preattentively, by human perception, which is why they are called "preattentive variables". Colour hue, brightness, shape, size, orientation and texture are some of the first variables to be identified and that have been used in information design (Behrens, 2008).

As seen in Figure 6, within a matrix of yellow squares, a circle or a blue square would stand out at first glance. In the real world, this happens when, for example, we look at a street with a lot of traffic and identify the lights of an ambulance or of a police car.



**Figure 6.** Fundamental preattentive variables predominantly used in information design (Behrens, 2008)

These preattentive variables are very important for designers to create a good infographic. Steve Krug, usability expert, underlines this

dimension: “a fundamental requirement for web interfaces that equally applies to any successful infographic: Don’t make me think!” (Behrens, 2008: 25). As Behrens claims, “Information Design is the practice of enabling communication between unequal partners: data (complex, professional, condensed) on one side, and the user (unexperienced, impatient, inattentive) on the other” (*idem: ibidem*).

Fleming & Mills (1992) created the VARK Model of Learning which states that human beings use four styles to process information: visual (charts, maps, and diagrams), auditory (listening), read and write, and kinesthetics (by experiencing). “Fortunately, connections have been made recently between the illustrative elements of graphics and the retention rates of the information displayed – and these connections can help us all figure out how to have people remember our material” (Lankow et al., 2012: 30).

Having the VARK model in mind we can see that infographics not only inform but they can also teach more effectively than other types of mediums alone, especially when they effectively combine different types of mediums in one single infographic.

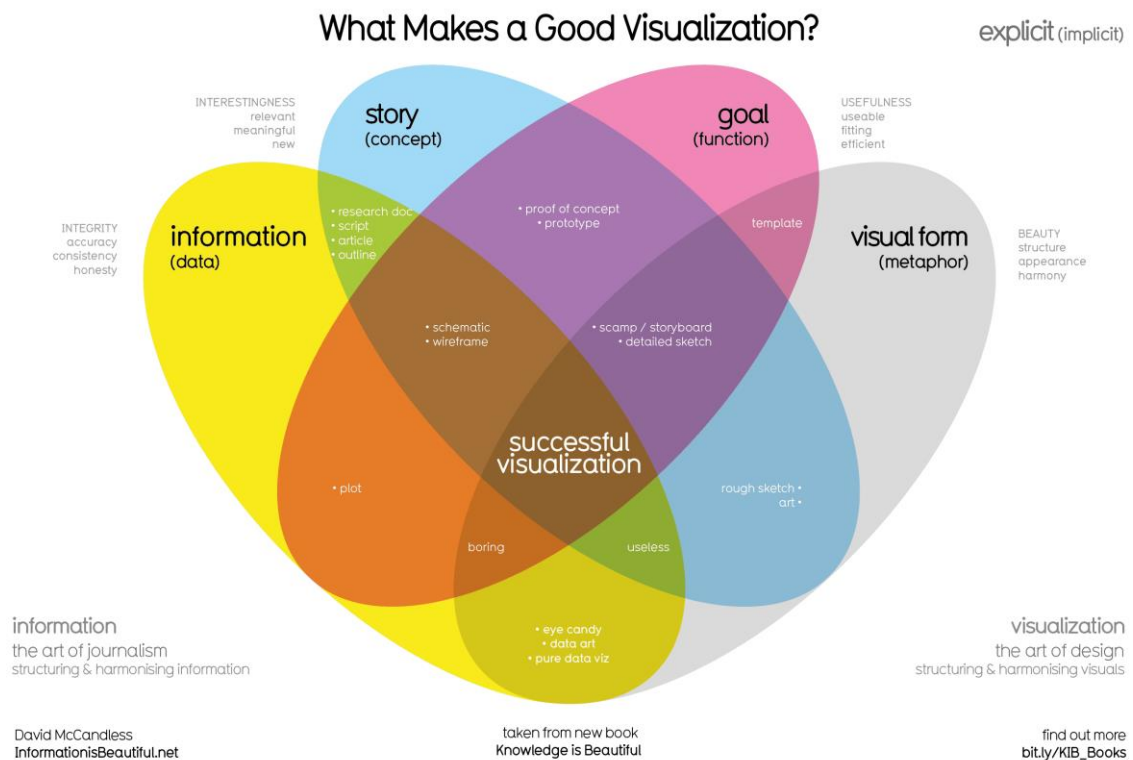
“The visualization of information is enabling us to gain insight and understanding quickly and efficiently, utilizing the incredible processing power of the human visual system” (*idem: 12*). As Finke *et al.* put it, infographics...

“(…) can be useful to employ a visual, symbolic metaphor to clarify the context of the graphic and rouse the viewer interest. For example, bank accounts can be represented by piggy banks, making the graphic more inviting without changing the content. It is important that the metaphor be appropriate to the statement and familiar to the target audience for the graphic to avoid misunderstandings.” (2012: 96).

For an infographic to communicate any subject, it must present the data efficiently, allow the free exploration of the data, be visually appealing, enable understanding of the information and make the knowledge memorable (Figueiras, 2013; Cairo, 2013; Lankow *et al.*, 2012).

Graphics should not simplify messages but instead they should clarify them, highlighting trends, uncovering patterns and revealing information that was not visible before (Cairo, 2013). It is important, though, that infographics don't fall on what Edward Tufte called a *chartjunk*, that is, a beautiful chart with no meaning nor information.

We have also seen that a narrative is an important part of infographics, especially when used for editorial purposes. David McCandless, author of the book *Knowledge is Beautiful*, wonderfully summarizes the components necessary for a good information visualization (Figure 7).



**Figure 7.** *What Makes a Good Visualization?* (McCandless)

As we can see in Figure 7, McCandless highlights information, story, goal and visual form as the main elements for a good information visualization, which is only successful when all components are combined. Otherwise they can easily be boring or useless: "Something that looks good but isn't that interesting" (McCandless, 2014)<sup>4</sup>.

As we have seen by now, infographics can be a powerful tool to communicate data, a subject, an idea or even a concept. As Cairo (2013) claims, "an infographic is a tool for the designer to *communicate* with readers, and a tool for readers to *analyse* what's being presented to them". Having that, infographics bring important benefits when it comes to the learning processes: enhances the ability to think critically and to

<sup>4</sup> <https://informationisbeautiful.net/visualizations/what-makes-a-good-data-visualization/>

develop and organize ideas; improves comprehension, retention and recall of information; helps reduce the cognitive load, leaving space to learn more new material.

They have the power to amuse the viewer at the same time it informs, teaches and even raises awareness. With that power, it helps solving analysis and comprehension problems.

## 2. CITIZEN OBSERVATORIES

In this chapter we will make a brief contextualization of the concept of Citizen Observatories, mentioning Citizen Science projects that have resorted to it. We will explore its origins, define it and highlight the importance of this concept both to science and society.

### 2.1. CONTEXTUALIZATION

Nowadays there is plenty information on Citizen Science (CS) (Cohn, J., 2008; Bonney *et al.*, 2009; Silvertown, 2009; Conrad & Hilchey, 2010; Bonter & Cooper, 2012; Hunter *et al.*, 2012; Jordan *et al.* 2012; Bonney *et al.*, 2014; Socientize Consortium, 2014; Jordan *et al.*, 2015; Liu *et al.*, 2017) that explain what it is, its origins and how it works.

On Citizen Observatories (CO), however, there is little information, maybe because it is a quite recent concept that began to make its first steps a few years ago (Liu *et al.*, 2017; Montargil & Santos, 2017). However, the European Union (EU) has already been investing significantly in Citizen Observatories' projects.

Citizen Science is a "partnership between those involved with science and the public in which authentic data are collected, shared and analysed" (Jordan *et al.* 2012: 307), that is, the "activities of non-scientist citizens that contribute to scientific research" (Liu *et al.*, 2017: 352).

These activities are very important because they allow scientists that lack time, resources and/or money to collect big amounts of data or to cover large geographic areas (Dickinson *et al.*, 2010; Tulloch *et al.*, 2013) while it raises awareness to scientific and societal problems.

According to Liu *et al.* (2017), there are three reasons for the expansion of CS in these last decades: (i) fast changes within Information and Communication Technologies (ICT's), such as easy Internet access, the expansion of social media and the improvement of collection,

management and storage of data; (ii) societal changes; and (iii) the scientists' increasing awareness of the benefits that come from the public engagement in the scientific work (data gathering, for example).

Before all this technology was available, the production of geographical information was a responsibility of national agencies, usually under the supervision of military control (Goodchild, 2007). These agencies conducted surveys and interviews to citizens to establish, for example, names of streets. The results of such interviews and questionnaires were then published in printed maps and, a few years later, on digital data sets (*idem*). However, these processes of getting information were too expensive for the governments to carry on, which allowed partnerships between the government and the private sector to come up with solutions that would be a lot more viable to proceed with the production of geographical information (*ibidem*).

Among these solutions emerged the concept of Community-Based Environmental Monitoring (CBM) system, which is "an organized way of collecting household level information at the local level for evidence-based policy making by local government units in partnership with national government agencies, NGOs and civil society for planning, program implementation and monitoring" (CBMS Network)<sup>5</sup>.

A few years later, and motivated by the emergence of Web 2.0 technologies, the concept of CBM evolved to Volunteered Geographic Information (VGI). VGI is the exploitation of tools to create, organize and disseminate geographic data by volunteers (Goodchild, 2007). Take as an example Google Earth, which service is used by millions of people and which Application Program Interface (API) "allows any user to create and publish new content, in the form of layers that can be viewed over the

---

<sup>5</sup> <http://siteresources.worldbank.org/PSGLP/Resources/CommunityBasedMonitoringSystem.pdf>  
[https://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/CBMS-GRB/METHODOLOGY\\_WORKSHOPS/Tool\\_fight.pdf](https://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/CBMS-GRB/METHODOLOGY_WORKSHOPS/Tool_fight.pdf)

Google Earth imagery base” (Goodchild, 2007: 8). Other similar examples include Flickr and OpenStreetMap.

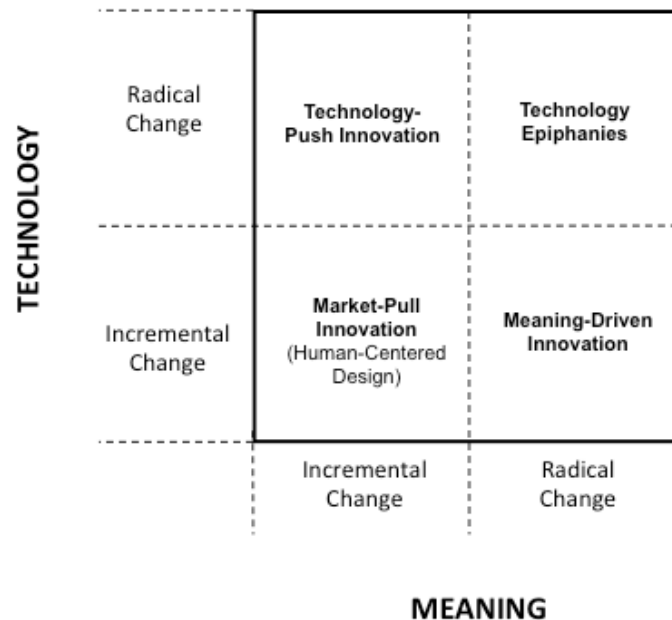
While CBM emerged as an answer to a problem - the gap of information between local and national government agencies -, VGI came to light because there was a sudden development of new technologies that allowed anyone, with or without specific knowledge, to take advantage of those technologies at the same time that provided important geographic information.

Citizen Observatories, as we will explain in detail on the next chapter, are used by the EU as a subsystem of Citizen Science that uses mostly smartphones to gather *in situ* information from an earth observation system (Montargil & Santos, 2017). The EU requires the cooperation of citizen observatories with global repositories of information from earth observation systems (such as the European Copernicus satellite program) and the Global Earth Observation System of Systems (GEOSS), where all data should be made available (European Commission, 2014).

Norman and Verganti, in their paper *Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change*, explore the evolution of innovation. They introduce two dimensions and four types of innovation (Figure 8) - Technology and Meaning dictate if an innovation is considered a Market-Pull, a Technology-Push, a Technology Epiphany or a Meaning-Driven Innovation:

“HCD [Human-Centred Design] leads to incremental change, and although it allows for local, linear changes in technology and meaning, basically it keeps the product within the lower left quadrant. Radical changes in technology can lead to radical technology-driven innovation: for example, the introduction of colour TV. Radical changes in meaning can lead to radical meaning-driven innovation, as in the switch from watch as tool to watch as fashion accessory. The biggest change comes about when both the technology and meaning change, as when Wii used

new technology and new meaning to radically change the space of video games. This dual change is rare and more dangerous: consumers tend to resist massive changes.” (Norman & Verganti, 2014: 12)



**Figure 8.** *The two dimensions and four types of innovation* (Norman & Verganti, 2014: 12)

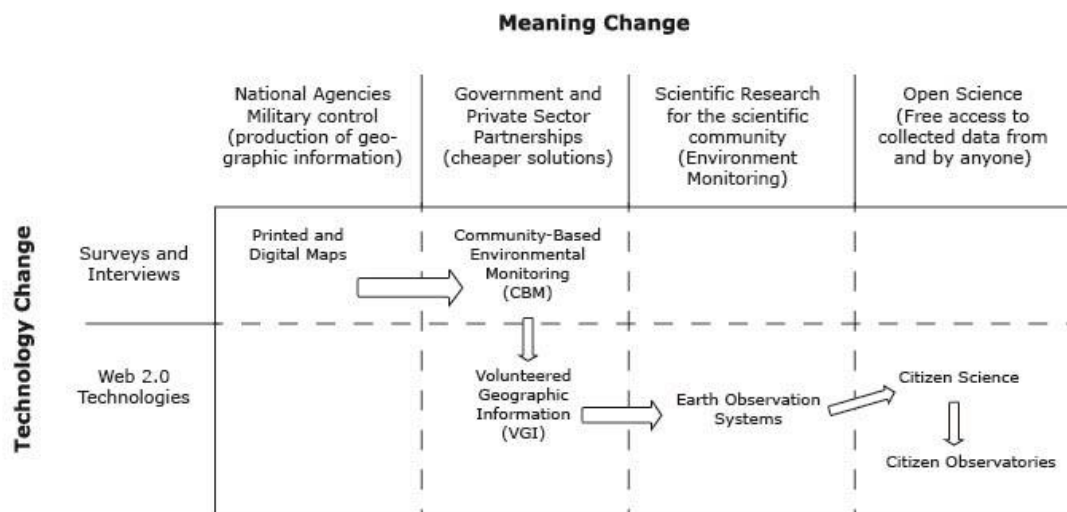
According to Norman and Verganti (2014), these types of innovation can be defined as:

- **Technology-Push:** this innovation comes from radical changes in technology but without change in the meaning of a product, nor with any influence of the user. Color TV is an example.
- **Meaning-driven innovation:** changes in socio-cultural models lead to radical changes in meanings and products, “often implying a change in socio-cultural regimes” (*idem*: 13), but without the interference of new technology. The mini-skirt in the 60’s is an example because the skirt was completely different from what was common, and became a symbol of women’s freedom (*ibidem*).

- **Technology Epiphany:** this type of innovation does not come from users because it does not satisfy a user's need. This occurs when a new technology emerges and brings with it a radical change in meaning. The Wii video game console is an example, because with new sensor technology, it allowed non-experts to play games controlled by body movements, in a time when Massively Multiplayer Role-Playing Online Games dominated the video games industry.
- **Market-Pull:** the analysis of users' needs leads to the development of new products that satisfy those needs.

Attending to the history and evolution of Citizen Observatories, we could see the innovation process as in the

Figure 9:



**Figure 9.** Citizen Observatories' innovation process

All in all, Citizen Observatories can be considered a process of technology push. That is, there was a change in the meaning of how to take advantage of the already existing technology. However, it was the emergence of Web 2.0 technologies that allowed VGI come to life. And then occurred another meaning change, which allowed ultimately the emergence of Citizen Science and Citizen Observatories.

However, as Montargil & Santos (2017) put it, CO cannot be only considered a process of technology-push innovation. Because CO depend so much on users' participation, "users' needs and expectations must be a central component from an early stage" (Montargil & Santos, 2017). This is why CO should (and must) have a strong market-pull innovation component as well (*idem*).

## 2.2. DEFINITION

Citizen Observatory is a relatively new concept. It was created in the follow up of the EU SOCIENTIZE project (2012-2014) and introduced in the project "Eye on Earth" (Liu *et al.*, 2014). However, this concept was only allowed to emerge because of the development of community-based environmental monitoring and volunteered geographic information (Montargil & Santos, 2017).

There are two main approaches to define Citizen Observatories: the one that focuses on citizens and the one that focuses on science. Both approaches are interesting and useful, however while the former worries about the understanding of citizens on environmentally-related problems, the latter worries about their contributions to gather more *in situ* information. Authors such as Liu, Kobernus, Broday and Bartonova stand for the societal approach. The European Commission, however, gives great relevance to the second.

Liu *et al.* (2014) define Citizen Observatories as "the citizens' own observations and understanding of environmentally-related problems, and particularly as reporting and commenting them" (Liu *et al.*, 2014: 4), usually using technological systems such as sensors, apps and other technological materials to promote communication and share data.

The European Union (EU), who started to invest on CO's in 2012, adopts a definition for CO's directly related to Earth Observation Systems (Montargil & Santos, 2017): "a citizen observatory is a subsystem that uses devices (mostly smartphones) operated by citizens to gather information used as *in situ* input from an earth observation system" (*idem*: 169; European Commission, 2014).

Earth Observation Systems use satellites for the observation of earth-related variables in a long-term perspective (Montargil & Santos, 2017), as well as use and integrate *in situ* information. For example, Copernicus is the European Earth Observation program (in partnership with the European Space Agency), designed specifically to collect data, through a specific set of systems, regarding six thematic areas: land, marine and atmosphere monitoring, climate change, emergency management and security. In 2018, this program celebrates its 20<sup>th</sup> birthday with seven satellites (called sentinels) in orbit that provide access to thousands of terabytes of free data. Its satellites are complemented by *in situ* sensors such as ground stations and ship- or buoy- sensors. The information collected by these sensors will help calibrate, validate and fill the information gaps provided by the satellites.

To increase the importance of citizen participation on environmental issues as well as raise awareness on decision-making policies, the EU developed five projects under the FP7 (Framework Programme 7) topic ENV.2016.6.5-1 *Developing community-based environmental monitoring and information systems using innovative and novel earth observation applications*:

- Citclops - Citizens' Observatory for Coast and Ocean Optical Monitoring. This project intended to develop "systems to retrieve and use data on seawater colour, transparency and fluorescence, using low-cost sensors combined with contextual information and a community-based Internet platform" (European Commission, 2014: 4). From October 2012 to September 2016;
- CITI-SENSE - Development of Sensor-based Citizens' Observatory Community for Improving Quality of Life in Cities. The purpose of this project was to develop and test "an environmental monitoring and information system focused on atmospheric pollution in cities and agglomerations" (European Commission, 2014: 4). From November 2012 to October 2016;
- COBWEB - Citizen Observatory Web. Development of a CO's framework to enable citizens "living in the UNESCO World Network of Biosphere Reserves (WNBR) to collect environmental information on a range of parameters including species distribution, flooding and land cover and use, giving them the opportunity to participate in environmental governance" (European Commission, 2014: 4). From November 2012 to October 2016;
- OMNISCIENTIS - Odour Monitoring and Information System based on Citizen and Technology Innovative Sensors. In this project citizens acted as human sensors to odour perception, discomfort and nuisance (European Commission, 2014). From October 2012 to September 2014;
- WeSenseIt - Citizen Observatory of Water. Addressed the "entire hydrologic cycle with a major focus on variables responsible for floods and drought occurrences" (European Commission, 2014: 5). From October 2012 to September 2016.

When these four FP7 projects finished, the EU funded a new set of four projects, under the Horizon 2020 programme. These projects started in 2016 and will run until 2019:

- Ground Truth 2.0 - "Environmental knowledge discovery of human sensed data". This is a three-year project that debuted on September 1<sup>st</sup>, 2016 and that is setting up and validating six citizen observatories in real conditions: four in Europe (Belgium, Netherlands, Spain and Sweden) and two in Africa (Kenia and Zambia). The focus of this CO project is on flora and fauna, water availability and water quality for land and natural resources management;

- LandSense - "Citizen Observatory and Innovation Marketplace for Land Use and Land Cover Monitoring". This project is building an innovative citizen observatory in the field of Land Use Land Cover (LULC), which collects data both actively (through citizens) and passively (from authoritative, and open access sources) and integrates them to provide valuable quality-assured in-situ data for SMEs, larger businesses, government agencies, NGOs and researchers;

- Scent. Running between 2016 and 2019, this project will engage citizens in environmental monitoring. It is intended that the citizens will support the monitoring of land-cover or use changes using their own smartphones and tablets and a toolbox developed specifically for this purpose;

- Grow Observatory. This project aims to engage thousands of growers, scientists and others passionate about the land, creating a sustainable ownership of land and soil, whilst meeting the demands of future food production. This will also help forecast and

prepare for climate events by validating the detection of soil moisture from a technology assisted by satellites.

### 2.3. WHY IS IT IMPORTANT?

“Every human is able to act as an intelligent sensor, perhaps equipped with such simple aids as GPS or even the means of taking measurements of environmental variables” (Goodchild, 2007: 9). CO's allow anyone interested to participate actively in observations and monitoring activities.

This brings a few advantages for science and community: it raises citizens' perception for the environmental and governmental issues; it enables dialog among scientists, the population and policy-makers which leads to a gain on economic value as it also raises the low or zero cost acquisition of data (Liu *et al.*, 2014; European Commission, 2014). Indeed, the cost-benefit ratio seems to be the most expected impact for the EU:

Lowered cost and extension of the in-situ component of the GEOSS and Copernicus initiatives. Better decision-making through the empowerment and active role of citizens and citizen's associations in environmental monitoring, co-operative planning and environmental stewardship, with special impact on land resources management. Enhanced implementation of governance and global policy objectives. Increased deployment and market uptake of innovative in-situ monitoring techniques. Increased European role in the business of in-situ monitoring of the environment.<sup>6</sup>

---

<sup>6</sup> [http://cordis.europa.eu/programme/rcn/664594\\_en.html](http://cordis.europa.eu/programme/rcn/664594_en.html)

The report *Citizens' Observatories: Empowering European Society Conference - Report Version 1.0*, published in 2014, in the very middle course of the first set of CO projects, also claimed that "the expected impact of these projects is the empowerment of citizens allowing them to influence environmental governance processes, providing models for decision-makers which facilitate connections between environmental governance, global policy objectives and citizens' needs" (European Commission, 2014: 4). As we can see so far, there is no clear and objective impact on the lives of these citizens for volunteering on these projects, besides their "empowerment".

As Montargil and Santos claimed, "one of the key issues about Citizen Observatories is mass participation" (2017: 171). We have seen before that the users' information and data will help validate, calibrate and fill gaps of sensors and satellites. If we think of country-sized projects, then it is needed a reliable network of a lot of people to guarantee a good territorial coverage. If we think of European-sized projects, then this network will naturally need to be bigger.

Besides being needed a great reliable network, we must not forget the participation in CO projects is on a volunteer basis. And this is why there is an urgent need to attract and keep citizens' interest and willingness to participate and engage on gathering and sharing information.

To ensure the citizens' effective participation, the EU will have to guarantee access to technological developments as well as (Liu *et al.*, 2014):

- i) Identify citizen needs and offers;
- ii) Explore possible products and services CO can provide;
- iii) Recruit and maintain citizen engagement;

- iv) Provide space and tools that support citizens to share observations;
- v) Supply tools that provide information.

In terms of data there are also concerns with the quality of the collected information as well as its privacy, security and interpretation (Liu *et al.*, 2014). Especially because these projects are relying on voluntary participation, there is a concern in the quality of the information.

All in all, CO projects still face two main challenges: the security and validation of collected data, and the mass participation. If we consider that having citizens willingly participating in these projects will increase the amount of data, the ones responsible for CO projects will then have to concern about the information validation. However, without mass participation from citizens, there will not be enough data to support the information from sensors and satellites.

A good communication plan is, therefore, needed. With a good communication strategy, CO projects will be able to attract and keep citizens engagement and willingness to participate. Having this in mind, we developed a project that will hopefully contribute to this communication strategy.

### 3. THE PROJECT

In this chapter we will explain where the idea of this project came from and its objectives. Furthermore, we will highlight the importance of this project and its feasibility, as well as the methodology we used to make it.

#### 3.1. JUSTIFICATION OF THE IDEA

This project is a result of my own academic, professional and personal experience. As a biologist, I have witnessed the struggle of many scientists to move forward with their investigations: they either lack funding or material resources. Even if they do have resources, during fieldwork they may even face the population misunderstanding and misconceptions.

As a science communicator, I have worked on many science events, either on hands-on activities or on tour guiding, and for what I have seen, both the public and the scientists really enjoy participating in such activities. In addition to it, and most important than that, both learn something from it and leave those events with a feeling of understanding.

As a student of multimedia with the opportunity of making use of all my skills and abilities to enlighten on a subject and concept and to make it accessible for all, I developed this project using the area I enjoy the most on multimedia: infographics.

Infographics is a subject mostly explored in "how-to" books and, academically, mostly applied to journalism. However, projects on infographics, that is, exploring the process of building an infographic to produce and share knowledge in the academic world, they are very rare. Within this gap, this is a project that intends to build an interactive infographic specifically to explain and enlighten on the concept of Citizen Observatories.

### 3.2. OBJECTIVES

CO projects run on a voluntary basis and we have seen that for it to be successful, citizens' engagement is crucial. There are several reasons for why someone would want to participate in these projects. Whether it is because someone has a problem which solution can be found in a CO project, or just because he/she enjoys science and wants to be part of a scientific project in his/her spare time, anyone can participate in these projects.

To recruit volunteers, it is very important to make information accessible. All ongoing projects of CO have their own websites (and a few have their own mobile apps) and general information on the concept can be found at the European Commission website. However, we think there could be a way to make the core information even more accessible and relatable.

Our main goal with this project is to build an infographic to communicate the concept of Citizen Observatories in a simple way. Considering the benefits of infographics for communication - including the use of images, interaction features and its shareability - we will use this tool to make CO's information more easily available to the public.

With this project, we also hope to contribute to the field of infographics. As we have mentioned before, infographics is widely explored in journalism, so bringing it to multimedia and science will hopefully bring a new perspective on its usability and advantages.

Finally, we hope that this project will increase awareness both to infographics and, especially, to Citizen Observatories. We expect the final result of this project to be used to spread information on that concept and, hopefully, to raise the willingness of citizens to engage in CO projects.

### 3.3. METHODOLOGY

Citizen Observatory is not an easy concept to be explained, especially graphically. Because one of our goals is to simplify and make this concept more accessible to everyone, we chose to use personas to build a relatable narrative around the CO concept.

A persona is a fictional person, made up for the purpose of helping people understand a given concept, idea or product. They are used mostly in marketing and publicity to help designers understand the behaviour and motivations of the target audience. They also help designers maintain focus and attention to the details that are really important. Personas represent a certain type of persons and standardize the approach of a group, which is why they become so relatable with the audience, and especially when built accordingly.

We decided to use three different personas, each one representing different scenarios: two with specific problems and one interested in citizen science. Inspired and based on the persona already sketched and proposed by Montargil and Santos (2017), we adapted and developed three personas for our own project:

- Ralf is a German amateur fisher, 35 years old, living in the Berlin area. He is a fishing enthusiast and fishes regularly in the many lakes and rivers surrounding Berlin but also, occasionally, in the sea. He is concerned about the water quality in his fishing locations because it will affect the quality of the fishes he catches. Therefore, Ralf has decided to buy a handheld sensor to monitor the water quality. This monitor can be connected to his mobile phone and, through an app, his measurements will be registered online. Ralf has shared publicly his sensor's information and enrolled in a citizens' observatory monitoring water quality. Ralf also has access to water quality measurements made by a public environmental

agency and by a network of professional fishers, through a network of fishing associations and professional institutions.

- Lisa is a Spanish entrepreneur, 24 years old, living in Barcelona. She has always been interested in nature, especially birds. Lisa is a birdwatch enthusiast and that is why she takes advantage of weekends and holidays to go outside the city and make observations. While birdwatching, Lisa can take photos with her mobile phone and upload in a specific app for bird specialists and amateurs. The app uses the mobile phone GPS and the information provided by the users to associate the observations to a specific location. The users share publicly their observations' data and are able to discuss them in an online forum, with other users and bird specialists.
- Nohr is Danish contractor, 62, living in Arhus. He suffers from pollen allergies and other breathing conditions. Due to his job, he must travel frequently so he bought a small sensor that measures air quality. He can connect his smartphone to the sensor and measure the air quality on a regular basis. Besides, Nohr enrolled in a citizen observatory related to the air quality and pollution monitoring which allows him to share publicly and access his measurements and his own evaluation of the air, as well as get alerts through his phone and email.

Our infographic was built around these three personas and, step by step, we explained how these three citizens could engage in CO projects and either solve their problems or satisfy a curiosity of them.

The design process began with the research of information and data on the different projects. To better understand the whole process of building a CO project and, especially, of connecting with the public (i.e.,

recruiting volunteers), we contacted (by email) the responsible for the CO projects – both finished and on-going projects. We got answers from three projects (Annex I): SCENT, CitiSense and GROW. The feedback from all of them allied with the information provided from the websites of all CO projects (including the one from the European Commission) allowed us to produce one infographic that could simply explain this concept.

The infographic was designed for two versions, desktop and mobile, using the Adobe Illustrator program. After a process of sketching on the paper that took several weeks, we decided the type of icons and images we wanted to use. To make the process of designing faster, we resorted an online icons and images bank, registered and the chosen ones were adapted according to our storyline. When the infographics were complete on Illustrator, we used Adobe XD program to simulate the interactions and the behaviour the infographic would have.

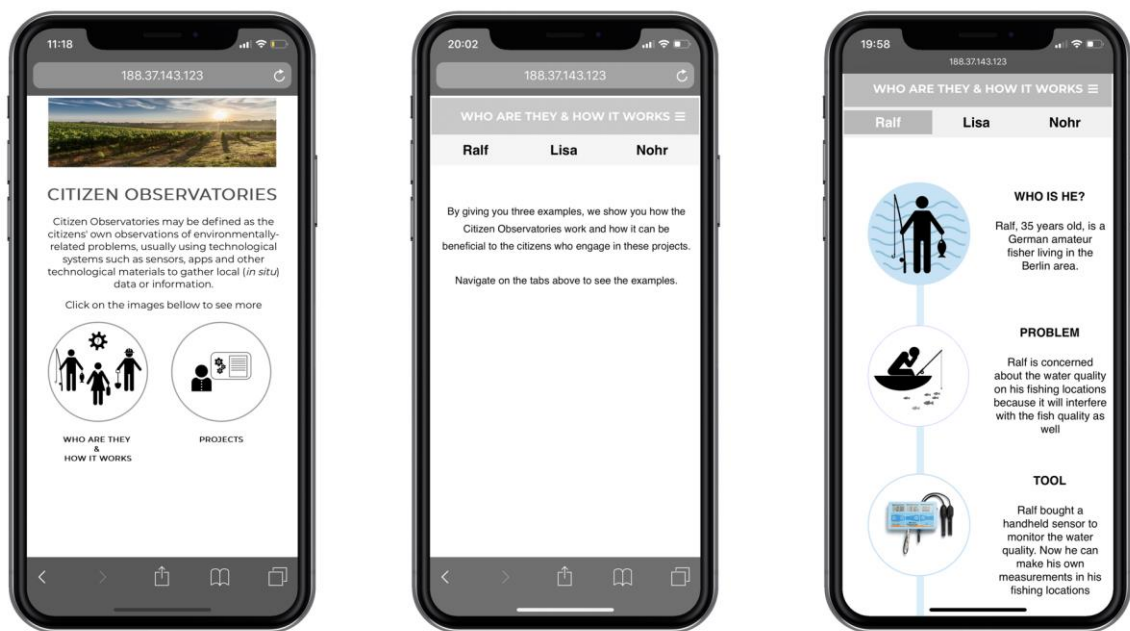
As I have mentioned before, we decided to take this project one step further by making our prototype a functional online infographic. In order to do so I coded the infographic, using HTML5, CSS and JavaScript, and made it available online by hosting it on a personal server. We also used a domain service which forwards the information to my server and makes it easier to spread the infographic. Then, when it was all set, we decided to test it with the contribution of a class at the School of Communication and Media Studies (Escola Superior de Comunicação Social), in Lisbon, with Erasmus students.

Because not all of them had computers, we gave these students access to the mobile version and let them explore it at their own pace. We also gave them a little simple survey (Annex II) to know about their experience with the infographic. With this activity we wanted to know if the infographic was intuitive, informative and well design so that anyone with or without knowledge on the subject would understand its content.

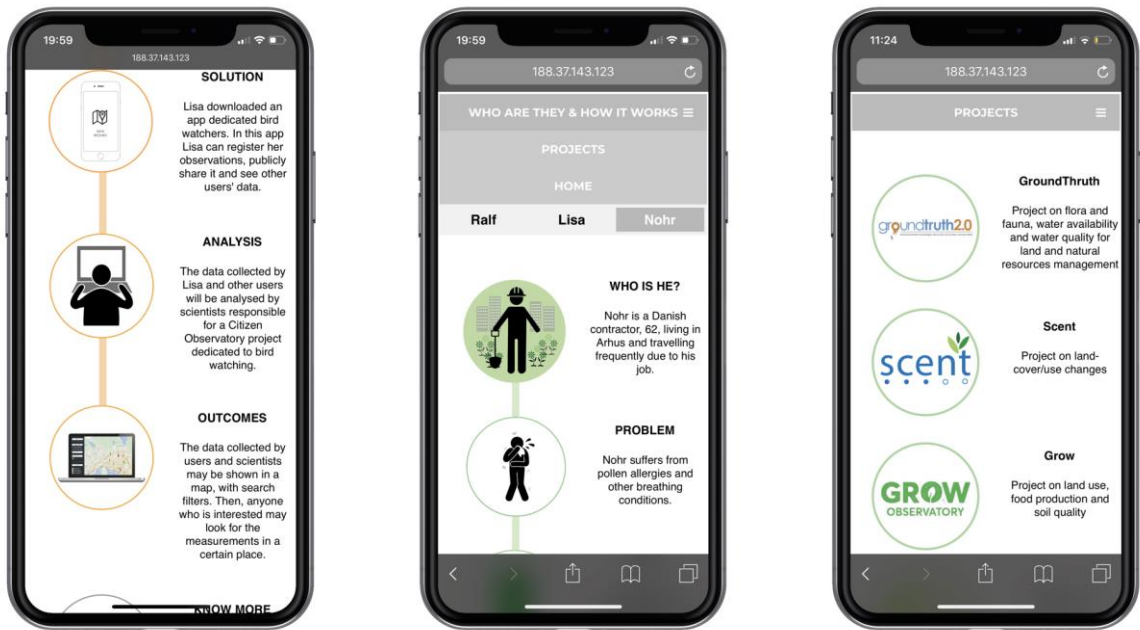
To test the desktop version, we used a Journalism class at the School of Communication and Media Studies, held in a computer lab. The methodology was exactly the same: we gave the students access to the desktop version, delivered the survey and let them explore and answer it at their own pace. For both groups of students, they took about 15 minutes to go over the whole process.

### 3.4. RESULTS

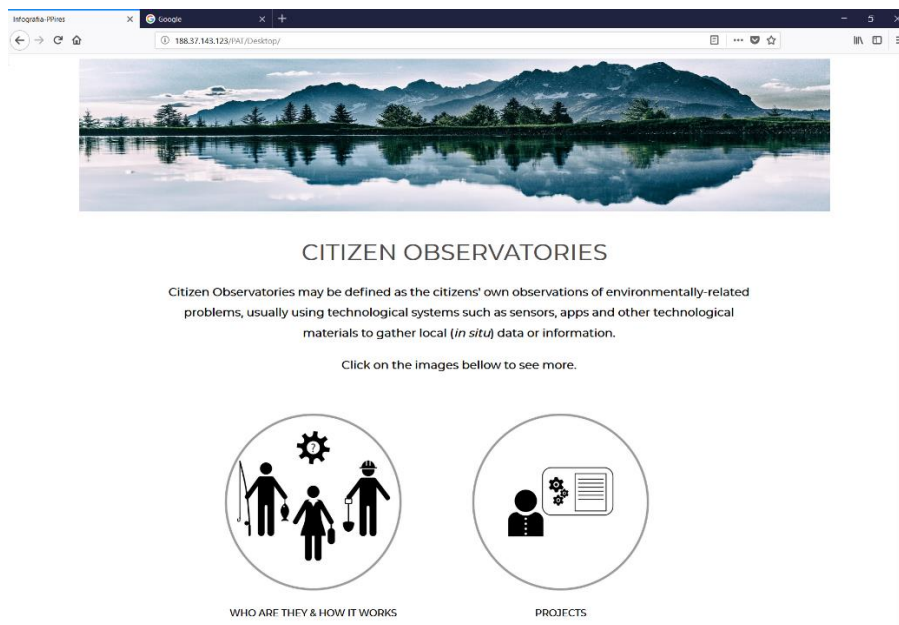
The result from the designing process is shown on the following mock-ups and print screens:



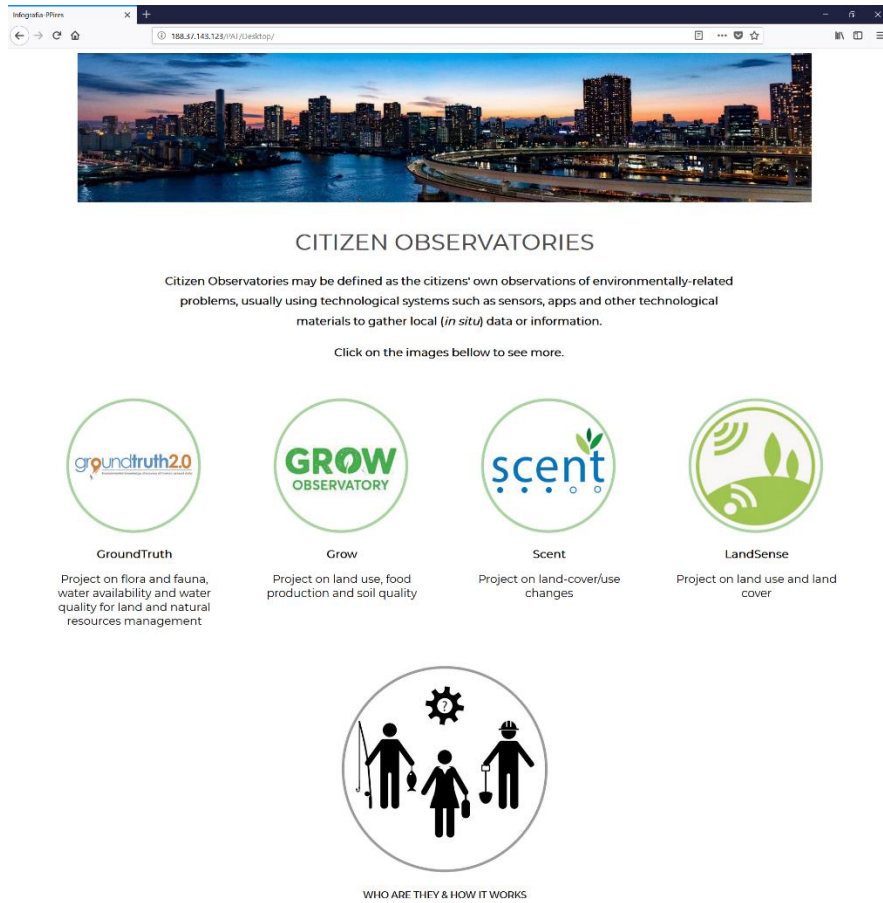
**Figure 10.** Mockups of the mobile version: homepage, personas front page, example of a persona



**Figure 11.** Mockups of the mobile version: persona page, drop menu, projects page



**Figure 12.** Print screen of the desktop homepage



**Figure 13.** Projects page on the desktop version

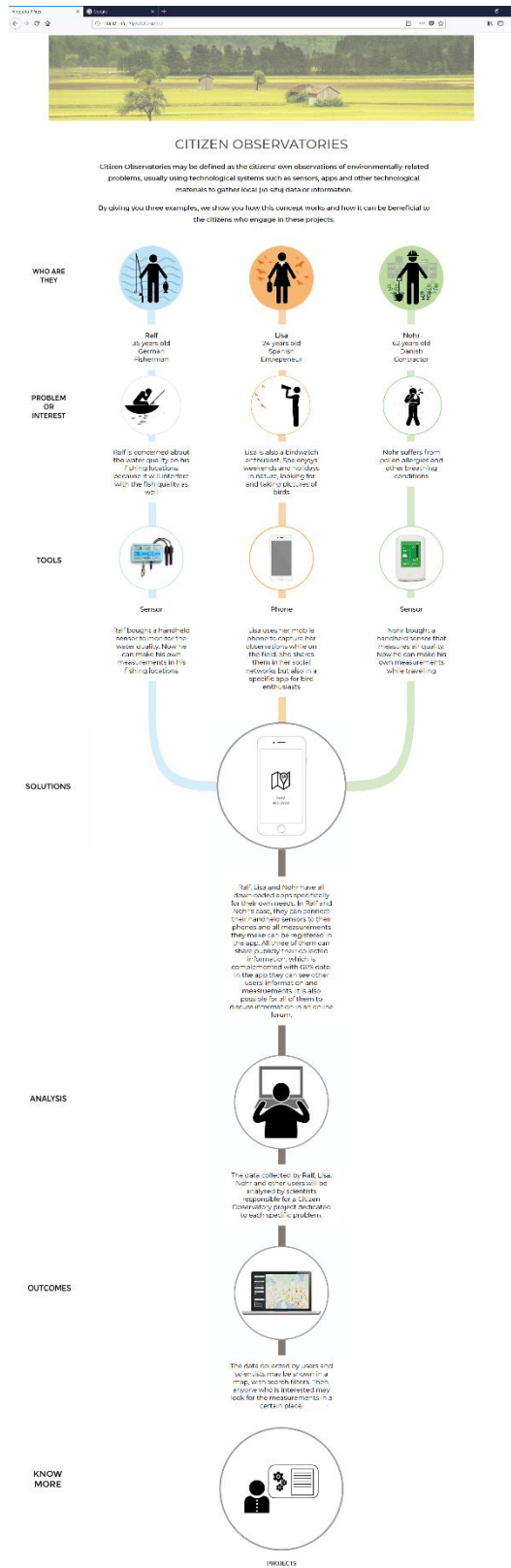


Figure 14. Personas page on the desktop version

For the final and functional versions, click on the following links:

- Mobile version - <http://mobileinfographics.ddns.net/>
- Desktop version - <http://desktopinfographics.ddns.net/>

Regarding the surveys, a total sample of 28 valid questionnaires was obtained (15 Erasmus students, evaluating the mobile version, and 13 Portuguese students, evaluating the desktop version). Even though the sample must be considered small, it is adequate for an exploratory analysis.

The first group, that analysed the mobile version of the infographic, was very diverse in terms of nationalities: Estonian (1), Polish (3), Romanian (2), Danish (2), Italian (1), Spanish (2), Belgian (2), French (1) and one that did not identify. In terms of gender, they were also very equally distributed, with 8 women, 7 men and one not identified, all in their early twenties. Their academic background was journalism and communication.

Of all the respondents, only one claimed to know what CO's were, prior to the analysis of this project. We then asked them to tell us, from 0 (Not easy at all) to 7 (super easy), how easy it was for them to understand the concept of CO through the infographic and how easy it was for them to navigate in the infographic. The results show us it was easy in both cases, being the navigation a little easier (average=6,13) than the understanding of the concept (average=5,53).

These results are in agreement with the information the respondents gave us when asked if they found every information they looked for. Only two out of the sample of 15 answered "No". One of them later explained on the survey that he/she wasn't looking for any information, and the second one told us that there was missing "more information to why it is useful and how I can use it and why should I".

We also asked the students if they thought the infographic was visually appealing. Three said no, two did not answer at all and 10 answered "Yes". To complement this information we also asked them if they thought the icons and the images used on the infographic were adequate to communicate the concept. Except for one person that did not answer, all other respondents answered "Yes" to that question.

To understand if the infographic was really effective, we asked the students to write a little definition on Citizen Observatories, based on the interaction they had. Here are a few examples of those answers:

*Collection of data done by regular people in their field of interest that can be used by scientists to make more valid and trustworthy conclusions about the matter*

Estonian student, 20 years old, did not know about CO

*People who are looking for solutions to some problems.*

Romanian student, 19 years old, did not know about CO

*Platforms that help to improve our lives.*

Spanish student, 23 years old, did not know about CO

*Normal people who track daily habits/activities and share that data with others through apps/websites.*

Belgian student, 20 years old, did know about CO

*It are observations everybody can cooperate with to help scientists (and people who are interested) to know more about what is observed.*

Belgian student, 22 years old, did not know about CO

At last we asked the respondents to tell us about what they enjoyed the most and the least about the infographic. Nine out of the 14 students that answered to the former question told us that the simple visualization and iconography were the best part of it because it made the information very easy to be understood. Three respondents told us that the navigation and interaction on the infographic was very good and another two referred the examples as the thing they liked the most out of the infographic.

Regarding the last question, on what they liked the least about the infographic, five out of the 12 students that answered, talked about a lack of information, both on numbers or percentages, and reasons why this COs are important and why people should adhere to it. Two respondents talked about how similar the examples were, and four mentioned a few technicalities such as a lack of background colour or a longing loading time. Last but not the least, one student told there was nothing she didn't like about it and that it was perfect.

The desktop version was tested amongst a class of 13 Portuguese students of journalism. The survey was exactly the same as the mobile one except for the link the students had to run on their computers.

The class was mainly composed by women (11 out of 13) in their early twenties, and similarly to what happened in the previous class, only one of the students knew about Citizen Observatories prior to this interaction. These students also claimed the concept was quite easy to understand (average of 5,92 out of 7) and to navigate in the infographic (average of 6,54 out of 7). Unlike the foreign students, in this class they all claimed to have found every information they looked for in the infographic.

Twelve out of thirteen students told us they found the infographic visually appealing, and all 13 students claimed the iconography was

adequate to communicate the information. These answers are in agreement with the definitions the students gave us on Citizen Observatories:

*These are the observations made by citizens about environmental problems, usually made through applications or other platforms.*

19 years old, did not know about CO

*They are people who are looking for solutions to environmental problems they face everyday. For this they resort to technology, a more efficient, efficient and updated means.*

20 years old, did not know about CO

*They are observations that people can make and communicate through apps about certain issues. These observations rely on relevant data gathered with technological devices and people's considerations.*

21 years old, did not know about CO

*Tools that collect and aggregate data related to certain environmental factors.*

20 years old, did know about CO

*Citizen Observatories is a project whose aim is to study the environmental problems observed by citizens themselves..*

20 years old, did not know about CO

Finally, we also asked these students what was the thing they liked the most and the least about the infographic. Regarding the former, five respondents claimed that the examples were the one thing they liked the most, five mentioned the simplicity and easiness of understanding the information, and three students added to it the fact that it had components of interactivity. On the things they enjoyed the least, seven respondents mentioned they felt there was a lack of information regarding either the personas or the projects, in the sense they ended their analysis and wanted to know more about the projects and the personas situations. Two students told us the infographics should have been a little more interactive, one did not like the initial page and three said there was nothing they did not like about the infographic.

As we will see in the following section, these results were very important for us to get some insight on the project we developed.

### 3.5. FINAL REMARKS

Even though the sample of this survey was small, it was very diverse and provided us a good preliminary insight on the work developed throughout the project. It was very important for us to have journalism and communication students to experience the infographic because, with or without knowledge on Citizen Observatories, they could give us a more accurate insight on the effectiveness of the infographic on a communication point of view. Furthermore, we believe it was an advantage for this work to have foreign students analysing the infographic. Citizen Observatories are initiatives funded by the European Commission, which take action in several countries of Europe, so it is important for us that people from a range of European countries can try out our project and give us their insight on the infographic.

As we could see by the results, both groups of students had very similar answers to the questions of the survey. Overall they thought it was easy to understand the concept - which was proved by the definitions they gave us and a few comments left on the most liked parts of the infographic -, and easy to navigate - which was also proved by the comments a few students left on the box of things they enjoyed the most. Most of them also thought the infographic was visually appealing and the iconography was adequate to communicate on the subject. This is in agreement with the fact that most of them also told us that one of the things they enjoyed the most about this infographic was the fact that it was simple and easy to understand.

The critiques to the infographic are as important for us as the compliments. We got a few comments saying that it could be richer in information, especially because by the end of the interaction the students were left curious about the subject and wanted to know more. This was actually a positive comment for us because it showed us the students understood the concept (by the other answers) but wanted to know even more about it and the projects. This means that our goal of increasing the interest on CO projects is being achieved. We also registered comments, especially from the foreign students, claiming that they wanted to see more information on why they should engage with CO projects and how it would be beneficial for them. Even though we take into account these comments, we must mention that the students analysed the infographic for 15 minutes and it could be possible that they did not pay attention or took the time necessary to think of what they were analysing. Despite that being the case or not, this information is very important for us as well.

In fact, all the comments and answers left on the surveys were important for us to know how to improve the infographic. We acknowledge that these surveys should have been done earlier in the

timeline of the project, in order to give us time to rectify some details. However, we were dependent on the beginning of the academic year, so these tests were conditioned by the scholar calendar and could hardly be done in other circumstances. All in all, these tests are a preliminary overview on how the user would perceive the infographic. In order to know in more detail what exactly should be improved and how, we purpose for further works a more extensive survey, including people from a wider range of age, nationality and backgrounds.

With this project we were able to develop a functional infographic that explains quite clearly the concept of Citizen Observatories. Has we have mentioned before, our goal with this project was to bring something new and refreshing to the academic world regarding infographics. At the same time, we also wanted to raise awareness and interest for the concept of Citizen Observatories and, for a short group of people, we did. We believe that with further improvements and by spreading the infographic we would be able to reach a bigger audience.

All in all, this was a first step towards the improvement of the communication strategy of Citizen Observatories that could actually be applied to several other areas and concepts. As we have seen, infographics is a powerful tool, especially when used with care and caution because it makes the communication process easier and accessible for all.

We hope this project inspires students and other people to pursue different paths on studying infographics, and that they apply it to subjects they are passionate about. This project is the result of my own passions and ambitions: I have enjoyed infographics for a long time now and I really wanted to improve the communication on a subject that is dear to me. And even though I am not a designer nor an expert in coding, I was still able to develop this complete and functional infographic.

## REFERENCES

### Bibliography

- Behrens, C. (2008). *The Form of Facts and Figures: Design Patterns for Interactive Information Visualization*. Master Thesis for the attainment of the degree Master of Arts in Design, University of Applied Sciences.
- Beniger, James R., Robyn, Dorothy L. (1978). "Quantitative Graphics in Statistics: A Brief History". *The American Statistician*, 32:1, 1-11. DOI 10.1080/00031305.1978.10479235. Available in: <https://www.tandfonline.com/doi/abs/10.1080/00031305.1978.10479235>
- Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Philips, T., Rosenberg, K. V., Shirk, J. (2009). "Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy". *BioScience*, 59(11): 977-984. <http://www.bioone.org/doi/full/10.1525/bio.2009.59.11.9>.
- Bonney, R., Shirk, J. L., Philips, T. B., Wiggins, A., Ballard, H. L., Miller-Rushing, A. J., Parrish, J. K. (2014). "Next Steps for Citizen Science. Policy Forum". *Science Magazine*, Vol 343, 1436-1437.
- Bonter, D. N., Cooper, C. B. (2012). "Data validation in citizen science: a case study from Project FeederWatch". *Frontiers in Ecology* 10(6):305-307. DOI: 10.1890/110273.
- Cairo, A. (2005). "Sailing to the future: infographics in the internet era". Multimedia Bootcamp, University of North Carolina at Chapel Hill.
- Cairo, A. (2008). *Infografía 2.1: Ensayo sobre el futuro de la visualización de información, Appendix of Infografía 2.0: Visualización interactiva de información en prensa*. Alamut. Madrid, Spain. ISBN: 978-84-9889-101-5.

- Cairo, A. (2013). *The Functional Art: An introduction to information graphics and visualization*. Berkeley, New Riders. ISBN-13: 978-0321834737.
- Cohn, J. P. (2008). "Citizen Science: Can Volunteers Do Real Research?" *BioScience*, Vol 58(3):192-197.
- Conrad, C.C., Hilchey, K. G. (2010). "A review of citizen science and community-based environmental monitoring: issues and opportunities". *Environ Monitor Assess* Vol.176: 273-291. DOI 10.1007/s10661-010-1582-5.
- De Pablos, J. M. (1999). "Infoperiodismo: el periodista como: creador de infografía". *Madrid: Síntesis*.
- Dickinson, J.L., Zuckerberg, B., Bonter, D.N. (2010). "Citizen Science as an Ecological Research Tool: Challenges and Benefits". *Annual Review of Ecology, Evolution, and Systematics* 41: 149–172.
- Norman, D. A. & Verganti, R. (2014). "Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change", *Design Issues* (Winter), Vol. 30, No. 1: 78–96, available in: [https://www.researchgate.net/publication/264595739\\_Incremental\\_and\\_Radical\\_Innovation\\_Design\\_Research\\_vs\\_Technology\\_and\\_Meaning\\_Change](https://www.researchgate.net/publication/264595739_Incremental_and_Radical_Innovation_Design_Research_vs_Technology_and_Meaning_Change). Retrieved September 20<sup>th</sup>, 2018.
- European Commission. (2014). "Citizens' Observatories: Empowering European Society Conference Report Version 1.0", available in: <http://citizen-obs.nilu.no/Portals/25/Downloads/Citizens%20Observatories%20Conference%20Reportv1%200.pdf>. Retrieved December 9<sup>th</sup>, 2017.
- Figueiras, A. (2013). "A Typology for Data Visualization on the Web". *17<sup>th</sup> International Conference on Information Visualization*. Pp351-359.
- Figueiras, A. (2014). "How to Tell Stories Using Visualization". *18<sup>th</sup> International Conference on Information Visualization*. Pp18-26.

- Figueiras, A. (2015). "Towards the Understanding of Interaction in Information Visualization". *19<sup>th</sup> International Conference on Information Visualisation*. Pp140-147.
- Finke, T., Manger, S. & Fichtel, S. (2012). *Infomotion: Animated Infographics*. Berlin, Gestalten. ISBN-10: 9783899554151.
- Fleming, N.D. & Mills, C. (1992). "Not Another Inventory, Rather a Catalyst for Reflection". *To Improve the Academy*, 11, 137-155.
- Giovanni, B. (1987). *Assim o homem inventou a comunicação*. In: Giovanni, Giovanni (Coord.). *Evolução da Comunicação: do sílex ao silício*. Tradução de Wilma Freitas Ronald de Carvalho. Rio de Janeiro: Nova Fronteira.
- Goldin, Paul R. (2018). "Xunzi", *The Stanford Encyclopedia of Philosophy* (Fall 2018 Edition), Edward N. Zalta (ed.), available in: <https://plato.stanford.edu/archives/fall2018/entries/xunzi/> . Retrived on October 1<sup>st</sup>.
- Goodchild, M. F. (2007). "Citizens as sensors: web 2.0 and the volunteering of geographic information", *GeoFocus* (Editorial), nº 7, p. 8-10, ISSN: 1578-5157.
- Hunter, J., Alabri, A., Ingen, C. (2012). "Assessing the quality and trustworthiness of citizen science data". *Concurrency and Computation: Practice and Experience*. DOI: 10.1002/cpe.2923.
- Jensen, E. & Buckley, N. (2012). "Why people attend science festivals: interests, motivations and self-reported benefits of public engagement with research". *Public Understanding of Science*, 1-21.
- Jordan RC, Ballard HL, Phillips, TB. (2012). "Key issues and new approaches for evaluating citizen-science learning outcomes". *Frontiers in Ecology and the Environment*. 10:307-309.
- Jordan, R., Crall, A., Gray, S., Philips, T., Mellor, D. (2015). "Citizen Science as a Distinct Field of Inquiry". *BioScience* 65: 208–211.

- Lankow, J., Ritchie, J. & Crooks, R. (2012). *Infographics: The Power of Visual Storytelling*. Nova Jérsea, John Wiley & Sons, Inc. ISBN: 978-1-118-31404-3.
- Liu, H-Y, Grossberndt, S., Kobernus, M. (2017). "Citizen Science and Citizens' Observatories: Trends, Roles, Challenges and Development Needs for Science and Environmental Governance". In: Foody, G, See, L, Fritz, S, Mooney, P, Olteanu-Raimond, A-M, Fonte, C C and Antoniou, V. (eds.) "Mapping and the Citizen Sensor". Pp. 351–376. London: Ubiquity Press. DOI: <https://doi.org/10.5334/bbf.o>. License: CC-BY 4.0.
- Liu, H-Y., Kobernus, M., Broday, D., Bartonova, A. (2014). "A conceptual approach to a citizens' observatory – supporting community-based environmental governance". *Environmental Health*, 13:107.
- Montargil, F. & Santos, V. (2017). "Citizen Observatories: Concept, Opportunities and Communication with Citizens in the First EU Experiences", in A. Paulin *et al.* (eds.), *Beyond Bureaucracy –Towards Sustainable Governance Informatisation*, Public Administration and Information Technology Series 25, DOI 10.1007/978-3-319-54142-6\_11167. Pp 167-184.
- Rodrigues, A. (2013). "Visualização de dados na construção infográfica: abordagem sobre um objeto em mutação". Available in: <http://www.bocc.ubi.pt/pag/rodrigues-adriana-2013-visualizacao-dados-construcao-infografica.pdf>. Retrieved October 25th, 2017.
- Rogers, Y., Sharp, H., Preece, J. (2011). *Interaction Design: Beyond Human-Computer Interaction*. West Sussex: Wiley, 3<sup>rd</sup> Edition. ISBN: 978-0-470-66576-3.
- Sancho, J. L. V. (2001). *La infografia: técnicas, análisis y usos periodísticos*. Bellaterra: Universitat Autònoma de Barcelona, Servei de Publicacions. ISBN 8449021596.

- Schmitt, V. (2006). "A Infografia Jornalística na ciência e tecnologia: um experimento com estudantes de jornalismo da Universidade Federal de Santa Catarina". Dissertação de Mestrado. Universidade Federal de Santa Catarina, Florianópolis.
- Schwartz, Benjamin I. (1985). *The World of Thought in Ancient China*. Cambridge, MA.: Harvard University Press. ISBN 0-674-96190-0.
- Sheth, B. R., Sharma, J., Rao, S. C., Sur, M. (1996). "Orientation Maps of Subjective Contours in Visual Cortex". *Science, New Series*, Vol. 274(5295): 2110-2115. <http://www.jstor.org/stable/2891371> .
- Silva, W. (2010). "O Desenho da Notícia: Uma análise Semiótica da Infografia do Jornal de Fato". Dissertação para obtenção do título de Bacharel em Comunicação Social. Universidade do Estado do Rio Grande do Norte. Mossoró.
- Silvertown, J. (2009). "A new dawn for citizen science". *Cell Press. Trends in Ecology and Evolution*, Vol. 24(9): 467-471.
- Smiciklas, M. (2012). *The Power of Infographics: Using Pictures to Communicate and Connect with Your Audiences*. Pearson Education, INC. ISBN-13: 978-0-7897-4949-9.
- Socientize consortium. (2014). "White Paper on Citizen Science in Europe". European Commission.
- Tufte, E. R. (2001). *The Visual Display of Quantitative Information*. Second Edition. Graphics Press, Cheshire, Connecticut, USA. ISBN-10: 1930824130.
- Tufte, E. R. (2006). *Beautiful Evidence*. Cheshire, Graphics Press LLC. ISBN-10: 1930824165.
- Tulloch, A.I.T., Possingham, H.P., Joseph, L.N., Szabo, J., Martin, T.G., (2013). "Realising the full potential of citizen science monitoring programs". *Biological Conservation* 165:128–138.

- Walter, E., Gioglio, J. (2014). *The Power of Visual Storytelling: How to Use Visuals, Videos, and Social Media to Market Your Brand*. McGraw Hill Education. ISBN: 978-0-07-182400-2.
- Wagner, E. D. (1997). "Interactivity: From Agents to Outcomes". *New Directions for Teaching and Learning*, n°71. Jossey-Bass Publishers. Available in <http://scihub.cc/http://onlinelibrary.wiley.com/doi/10.1002/tl.7103/full>, consulted on 21 November 2017.
- Ware, C. (2004). *Information Visualization: Perception for Design*. 2<sup>nd</sup> ed. San Francisco, Morgan Kaufmann Publishers. ISBN-10: 9780123814647.

## ANNEXES

### **Annex I** – Emails

Citizen Observatory Questions

12 mensagens

Patricia Pires <patricia.m.m.pires@gmail.com> 22 de janeiro de 2018 às 15:44

Para: u.wehn@un-ihe.org

Cc: Cátia Mendonça <catiamendonca.escs@gmail.com>, Filipe Montargil <fmontargil@escs.ipl.pt>

Hello,

My name is Patrícia and I am a Portuguese student of the Master of Audiovisual and Multimedia of Superior School of Social Communication (ESCS IPL, Lisbon).

I am currently developing my final project which objective is to develop an infographic for the web on citizen observatories. This idea came also from my background (I have a degree in Biology and a master in Science Communication), so I am aware of the potential of Citizen Observatories and how important they are both for science and society.

I have seen the website of Ground Truth 2.0, however I still have some questions about the general process of putting together a citizen observatory project:

1. How do you approach citizens and "recruit" them as volunteers for your project? That is, how do you acknowledge citizens of your project? Is it just from meetings and talks?
2. How can people participate in your project? And who is eligible?
3. Who is responsible for explaining and enlighten on the citizens' questions?
4. The equipment that citizens have to have for the collection of data, if necessary, is purchased by the volunteers or is it given to them for free?
5. Is there any process of data validation? Who is the responsible for that validation?
6. Through the whole project, are the volunteers acknowledged of the outcomes of their contributions?

All in all I want to better understand the steps necessary for the development of a citizen observatory project; how you, as scientists, engage with citizens and how you acknowledge them of their contributions.

Having that I was wondering if you could spare a little of your time to enlighten me on these questions, either by email or over a skype call.

Thank you in advance for your attention,

Kind regards,  
Patrícia Pires

---

valantis.tsiakos@iccs.gr <valantis.tsiakos@iccs.gr> 11 de fevereiro de 2018 às 16:58

Para: patricia.m.m.pires@gmail.com

Cc: Athanasia Tsertou <atsertou@iccs.gr>, A.Amditis@iccs.gr

Dear Ms. Pires,

Thank you for your email. Kindly find below our response to your inquiry:

1. SCENT includes a vast number of outreach activities aiming to attract and encourage citizens' participation to the project. In addition, participation of the latter is facilitated by the composition of the team which includes non-profit voluntary organizations and NGOs that have access to a large network of citizen groups.
2. The project foresees two large scale demonstrations in Greece and Romania, where citizens will be able to participate and utilize Scent toolbox. There are no restrictions to participation. All people, and particularly those interested in the environmental policy making process are free to participate in the events.
3. During the demonstration period, various workshops and events will take place prior to the citizens' actual engagement, in order to be informed and trained to the use of Scent solutions. Apart from this, the project's website provides the possibility for the general public to contact the scientific team of the project for any further information that they may require.
4. Citizens will not have to purchase any equipment for data collection. They will be able to download the SCENT apps to their smartphones and then collect new data of the pilot sites.
5. Data collected though the Scent crowd-sourcing application will be validated in the context of a sophisticated back-end system, trained with real data.

6. The participation of citizens in the project is carried out in accordance with national and European rules on the protection of personal data. As part of the project's results, the co-operation of citizens with the consortium is described in detail, thus recognizing their contribution to the achievement of the project's objectives. Hope this clarifies your concerns about Citizen Observatories.

Please do not hesitate to contact us, in case you need any further information.

With best regards,

Valantis

Valantis Tsiakos  
GeoInformatics Engineer, Scientific Project Manager  
Smart Integrated Systems

Institute of Communication & Computer Systems (ICCS)  
9, Iroon Politechniou Str. Zografou, Athens GREECE  
Tel: +30-210-772-2526, Fax: +30-210-772-2291  
Web-Site: <http://i-sense.iccs.gr>

---

Alena Bartonova <Alena.Bartonova@nilu.no> 21 de fevereiro de 2018 às 12:32  
Para: Patricia Pires <patricia.m.m.pires@gmail.com>  
Cc: Filipe Montargil <fmontargil@escs.ipl.pt>, Cátia Mendonça <catiamendonca.escs@gmail.com>

Dear Patricia,

Thank you for your mail. I understand you have looked at the web site <http://co.citi-sense.eu>? We have two web sites, with this one providing most of the information.

On your questions:

1. How did you approach citizens and "recruited" them as volunteers for your project? That is, how did you acknowledge citizens of your project?

Please consult the deliverable D2.4, at <https://co.citi-sense.eu/TheProject/Publications/Deliverables.aspx>. How we approached citizens varied from city to city. Regarding how we acknowledge citizens, I am not sure what you exactly mean – whenever we use data generated by them we do say so. Further, for example in Oslo, we had a final citizen event where we explained the project results.

2. How could people participate in your project? What was the process for any voluntary to take to be part of your project?

Again, the same deliverable 2.4 should provide answers. Approaches varied from location to location. In Oslo for example, we used a number of recruitment strategies, from contacts with NGOs who have relevant activities, through science days of the Research Council, contact with bicyclists etc.

3. Who was responsible for explaining and enlighten on the citizens' questions? Was there any conversation between the scientists engaged in this project and the volunteers or it was all done through the website and social networks?

Personal contact with all volunteers. Social media were only used for outreach, not for data collection.

4. Taking your CityAir App as an example, anyone with interest could download it and use it to measure the perceived quality of air in a given region. As this is somehow subjective data, was there any process of data validation? Who was the responsible for that validation?

We can not validate subjective data. So, the answer is nobody. The app is still active if you would like to have it used, we can support the data extraction.

5. Through the whole project, were the volunteers acknowledged of the outcomes of their contributions?

Not sure what you are asking. Please look at the deliverables in the co.citi-sense.eu web site and if you do not get an answer from there, contact me again.

All the best

Alena

---

GROWObservatory <grow@dundee.ac.uk>

21 de fevereiro de 2018 às 11:20

Para: Patricia Pires <patricia.m.m.pires@gmail.com>

Cc: "Deborah Long (Staff)" <d.long@dundee.ac.uk>, "Raquel Ajates Gonzalez (Staff)" <r.ajatesgonzalez@dundee.ac.uk>

Dear Patricia

I have picked up your email to hello@growobservatory.org as well as to Dr Drew Hemment, the lead for the GROW Observatory. I have passed it to some of the citizen science specialists within our project and they will respond to you as soon as possible! You will of course learn a lot more about how GROW operates by following the pathways for participants through our courses and by taking part in activities, experiments and

joining the online community. However we do wish to support your research within our capacity so we will try to find time for someone to respond more directly to you.

Kind regards

Amanda

Amanda Wilman  
GROW Observatory Communications Officer  
University of Dundee/DJCAD

GROW Observatory  
GROW food. GROW soil. GROW science.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690199.

Information contained in this email is confidential and must be kept as such until given explicit notice of publication

## Annex II – Surveys

### SURVEY ON INFOGRAPHICS

In the scope of the final work for the Master Degree on Audiovisual and Multimedia, I developed an Infographic on Citizen Observatories (CO). Now, as a final part of my project, I designed this survey to better understand how the user will perceive it.

I kindly ask you to analyse this link <http://desktopinfographics.ddns.net/> for 5 to 10 minutes and then answer the questions below. This survey will take you only 5 minutes. Thank you so much!

<p>1) Before interacting with the infographic, did you know anything about Citizen Observatories?</p> <p><input type="checkbox"/> No <input type="checkbox"/> Yes</p>	<p>5) In the infographic, did you find every information you looked for?</p> <p><input type="checkbox"/> No <input type="checkbox"/> Yes</p>	<p>9) After interacting with the infographic, what do you think CO are?</p> <div style="border: 1px solid black; height: 40px; width: 100%;"></div>
<p>2) If you answered YES to the previous question, tell us what (projects, volunteering...)</p> <div style="border: 1px solid black; height: 25px; width: 100%;"></div>	<p>6) If you answered NO to the previous question, tell us what do you think was missing:</p> <div style="border: 1px solid black; height: 45px; width: 100%;"></div>	<p>10) What did you like the most about this infographic?</p> <div style="border: 1px solid black; height: 40px; width: 100%;"></div>
<p>3) From 0 to 7, how easy for you was to understand the concept of CO after analysing the infographics? (0=Not easy at all; 7=Super easy)</p> <p><input type="radio"/> 0   <input type="radio"/> 1   <input type="radio"/> 2   <input type="radio"/> 3   <input type="radio"/> 4   <input type="radio"/> 5   <input type="radio"/> 6   <input type="radio"/> 7</p>	<p>7) Do you think the infographic was visually appealing?</p> <p><input type="checkbox"/> No <input type="checkbox"/> Yes</p>	<p>11) What did you like the least about this infographic?</p> <div style="border: 1px solid black; height: 40px; width: 100%;"></div>
<p>4) From 0 to 7, how easy for you was to navigate in the infographic? (0=Not easy at all; 7=Super easy)</p> <p><input type="radio"/> 0   <input type="radio"/> 1   <input type="radio"/> 2   <input type="radio"/> 3   <input type="radio"/> 4   <input type="radio"/> 5   <input type="radio"/> 6   <input type="radio"/> 7</p>	<p>8) Do you think the icons/images were adequate to communicate the information?</p> <p><input type="checkbox"/> No <input type="checkbox"/> Yes</p>	<p>Gender: _____      Age: _____ Nationality: _____ Field of studies: _____</p>

**Figure 15.** Survey on the desktop version of the infographics

## SURVEY ON INFOGRAPHICS

In the scope of the final work for the Master Degree on Audiovisual and Multimedia, I developed an Infographic on Citizen Observatories (CO). Now, as a final part of my project, I designed this survey to better understand how the user will perceive it.

I kindly ask you to analyse this link <http://mobileinfographics.ddns.net/> for 5 to 10 minutes and then answer the questions below. This survey will take you only 5 minutes. Thank you so much!

1) Before interacting with the infographic, did you know anything about Citizen Observatories?

- No  
 Yes

2) If you answered YES to the previous question, tell us what (projects, volunteering...)

3) From 0 to 7, how easy for you was to understand the concept of CO after analysing the infographics?

(0=Not easy at all; 7=Super easy)

0  1  2  3  4  5  6  7

4) From 0 to 7, how easy for you was to navigate in the infographic?

(0=Not easy at all; 7=Super easy)

0  1  2  3  4  5  6  7

5) In the infographic, did you find every information you looked for?

- No  
 Yes

6) If you answered NO to the previous question, tell us what do you think was missing:

7) Do you think the infographic was visually appealing?

- No  
 Yes

8) Do you think the icons/images were adequate to communicate the information?

- No  
 Yes

9) After interacting with the infographic, what do you think CO are?

10) What did you like the most about this infographic?

11) What did you like the least about this infographic?

Gender: \_\_\_\_\_ Age: \_\_\_\_\_

Nationality: \_\_\_\_\_

Field of studies: \_\_\_\_\_

**Figure 16.** Survey on the mobile version of the infographics