

# Visualising the contribution of whales as a natural solution for climate change

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## Abstract

It is common knowledge that the increase of carbon dioxide is very harmful to our planet, a perspective to solve this problem would be to understand how it will be possible to reduce pollution production, however, this thesis aims to present a natural mechanism for capturing  $CO_2$  from the atmosphere.

This simple and essentially “no-tech” strategy to capture more carbon from the atmosphere increases global whale populations. Marine biologists have discovered that whales are very important to atmosphere, capturing a lot of  $CO_2$ , accumulating it in their bodies during their lives and sinking to the bottom of the ocean when they die. While a tree absorbs only up to 48 pounds of  $CO_2$  a year, each great whale sequesters 33 tons of  $CO_2$  on average.

These phenomena are hard to communicate to a wide audience so we tried to transmit the message with the contribution of this thesis using an interactive application to visualize the impact of whales as a natural solution for climate change. This thesis also reports on the development and testing of interactive 3D visualizations that are part of the application.

**Keywords:** Carbon Dioxide; Whales; Human-Computer Interaction; Visualization; Awareness

## 1. Introduction

What causes these climate changes are pollution and the consequent increase of carbon dioxide in the atmosphere, according to the Mauna Loa observatory, the growth rate is continuously rising. [1]

Thus, there are more and more initiatives aimed at removing carbon dioxide through the most varied forms, such as innovative projects and the protection of natural extractors. It is common knowledge that trees store the  $CO_2$  taken from the atmosphere through photosynthesis, what few people know is that whales also play a very important role and each one is equivalent to several trees.

This project aims to make the population aware of the benefits of whales however as is a very unknown solution is very difficult to communicate.

We conducted a study about whales' applications and platforms focused on the environment, and also analyse short visualizations because these solutions are more attractive and should be a better way to show how the whales are a natural solution for climate change.

This dissertation describes the process of building a technological platform that results in the combination of an application built with *React Native* and 3D visualizations developed in *Houdini*.

In short, the objective was to expose the theme

with positive framing, taking into account related works and users' research to evaluate the impact of interactive visualization and finally take conclusions.

## 2. Climate change visualizations

Applications and short videos are responsible for much of the time occupation of human beings who have been seduced by the digital era.

The use of smartphones and tablets among students is a rapidly growing trend [3], particularly at the time of lockdown caused by COVID-19. With thousands of apps available, there is a wide variety to suit students' needs, however, it is a big challenge to develop efficient code and produce a design that fits specific learning requirements. Research [8] about the influence of mobile apps in pedagogy and mobile devices as tools in educational interventions has revealed that the overall effect of using mobile devices in education is better than when using desktop computers since effectively communicating contents and concepts through educational apps reduces the cognitive load on the users with an easy and faster flow of information, according to a study about science learning carried out in a school [4].

Most recently a study [7] found a positive association between academic assistance and the inten-

tion to use educational apps during the COVID-19 pandemic because many students depended on educational apps for learning. An interesting fact about this work is that the high school and college students may be looking for more subject-specific content than entertaining content, unlike younger target audiences as proved by previous research [6].

Regarding videos, visual storytelling can make powerful contributions to helping people to overcome cognitive barriers, build emotional connections and, ultimately, change life choices to protect the environment. [5].

Nowadays we see that much of the time occupied by smartphone and tablet users is spent in applications, more specifically in social networks that are full of visualizations that absorb and make the users lose the perception of the time spent. Platforms like *Instagram*, *Facebook*, *YouTube*, *Twitter* and the most recent social network that significantly increased the download numbers, the technological phenomenon *TikTok*, have exactly the concept of short videos that are easy to watch and captivate the user and, if used well, can lead to assimilating interesting knowledge.

### 3. User Research

Users' researches are very important as a source of information, through which we have access to statistics about the preferences of people when looking for informative platforms.

The search for the need and how to build a solution is part of the user-centered design approach since the application must fit what the user needs and based on that we could idealize the features of our prototype.

With this in mind, before developing the application, a questionnaire was carried out to identify some key points in which 14 questions were asked through Google Forms to 89 people, and all the respondents answered the same questions.

#### 3.1. Survey

The intention of doing the survey was to create a more concrete idea of the hypothetical user of our project, on the one hand understanding the relationship with technological devices and on the other hand what they think about climate change.

The answers to the survey were given by people of all age groups, most of which were between 18 and 25 years old (33.3%) because initially we considered young people like our target audience since it is the age group of adults who will suffer most from climate change, however the more people know about the problem the better.

To develop the idea of what we were going to build we clarify that more than 55% of people prefer apps over websites.

More than 47% answered that they spend between two and four hours on the internet outside of work and approximately 54% use this time to watch videos, which helped us to bet on 3D visualization as a way of transmitting the information.

94.4% of respondents assumed that would spend some time on a computer or mobile phone for the benefit of the environment which led us to conclude that there could be a demand for a knowledge transmission application about climate change.

Of the 89 respondents, only one said that global warming does not concern him and regarding videos, more than 76% of the respondents revealed that they had already watched at least one related to climate change which many describe as scary or synonymous, despite this approach in the case of our project we will opt for a positive framing, communication through explanations of how whales can help the environment.

Around 3 in 4 people revealed that they had never used any environmental platform, which would be expected given the low supply and dissemination in the mobile application markets and make us believe that there is a gap in the offer for a solution as ours.

Finally, more than 76% of respondents believe that global warming has a solution, but only 17 out of 89 were aware that whales help to reduce carbon dioxide from the atmosphere and when asked about possible solutions no one pointed to oceans as one thus making us bring interesting new knowledge to those who use our app.

### 4. Proposed Solution

The initial part of the solution was to choose how we wanted to present the users the information about the whales, for this we believed that 3D videos, simple and dynamic graphs and succinct text information could hold the attention of the user. The next phase was to find out the technologies that fit better with the requirements described in the last paragraph.

After the technologies we selected the layout of the application screens and lastly the functional prototype was developed.

#### 4.1. Requirements

An application with explanatory 3D videos integrated to make the information more appealing was the first requirement and we wanted that our app could be exposed in a museum, school or a public space and to be one time used not a platform to use regularly.

After we defined the screens:

- **Cover** with title, a button to navigate to the next screen and the possibility of changing the

language

- **Menu** with three options about the phases of whale influence in carbon absorption and an explanatory text
- Three screens about whale influence in carbon absorption: With a video, dynamic graphs and explanatory texts

#### 4.2. Technologies

The architecture of our application is only built with a presentation layer. We made the flow very simple and intuitive, just concerned with the interaction between the user and the system.

To do a set of 3D visualizations we used a powerful technology called *Houdini* and *React Native* for the app development.

##### 4.2.1 Houdini

*Houdini* is a 3D animation software application that works in a procedural way, every action is stored in a node, which then is “wired” into networks that define a “recipe”. The ability for nodes to be saved and to pass information, in the form of attributes, down the chain is what gives *Houdini* its procedural nature.

It is a very known framework in the animation industry and does not require plugins, furthermore it has powerful animation tools, creating sophisticated particles (necessary for the ocean replication) and dynamic simulations, procedural workflow and a great built-in render called Mantra.

The main disadvantage that I had to point out is the render time that is too much, for example, a project video that has less than 50 seconds took more than 48 hours to render.

##### 4.2.2 React Native

*React Native* is a User Interface JavaScript framework, cross-platform for writing code that can render native mobile applications for iOS and Android.

It is based on React, characterized by encapsulated components that manage their own state. After each component is created we can share and join them to make complex UIs.

Another advantage of this framework is fast refresh, which allows seeing render changes as soon as the code was saved.

Furthermore there are much documentation online and we can use very well-designed and popular libraries.

In short was a good choice because the application had a great performance and we could do everything that we idealized.

#### 4.3. Application Features and Design Process

The core design of the application was made by Marta Ferreira after recurring brainstorms between all people involved in the project. The main goal was to reach users’ awareness through a simple, interactive, attractive and differentiated product with an intuitive flow.

Using the Research through Design method [9] the focus will be on empirical analysis to observe and measure performance, in other words, data from users will be acquired to be analyzed and guide the iterations of the prototype’s developments.

The objective of using this type of design method is to have an investigation designed to make an application that can have an impact on users to the point of making a social change, helping communication and engagement of an environmental issue.

#### 4.4. Functional Prototype

In the following subsections all screens will be described.

##### 4.4.1 Cover

A simple screen where the user can change the platform language between Portuguese and English. This is possible by a framework called *i18next* that manages files with the translations and detects the user language after the click in the flags.

In addition to language options, the screen has a round button that leads the user to the menu of the application.

##### 4.4.2 Menu

After the cover, the user navigates to a screen where is presented our persona, the whale Dory and below that three options with moments that are related to the carbon absorption.

Dependent on the button chosen by the user, properties (object argument with data) will be passed to the next screen through the navigation route. That way the next three screens are all the same but with some different components.

##### 4.4.3 Migration

The visualization was based on an article [2] that represents a whale that is moving from the cold waters of Alaska which is a foraging area around six months later arrives in the warm water of Mexico where it breeds.

Have two horizontal graphics that move according to the time of visualization and have data about  $CO_2$  absorption by whales and trees.

Finally have a static graphic with the information on the carbon dioxide produced on average by a person, the graphics are for the user to have a term of comparison.

#### 4.4.4 Pump

Consists of a visualization and a brief explanatory text that detail the exact moment when the whale returns to the surface to breath.

#### 4.4.5 Deadfall

The deadfall screen represents the last phase of the relation between the whale and carbon dioxide. A visualization together with text gives some details about what happens when the whale, with the carbon inside, dies and goes into the ocean deep.

A graph grows along with the video and the data are related to the whale's lifetime in terms of  $CO_2$  absorption.

### 5. Evaluation

#### 5.1. Methodology

In this section we will explain all the processes that led us to the results of the usability tests.

We used summative assessment to identify achieved goals and usability deficiencies existing in our solution and the evaluations were divided between qualitative and quantitative measures.

Was created a protocol guide to help us during the tests keeping all sessions as cohesive and similar as possible, this protocol is presented and we presented the same three forms and the task to all respondents.

It should also be noted that the tests were carried out in spaces where only the researcher and the user were present.

##### 5.1.1 Introduction, Consent Form and Initial Survey

To explain how would be the usability test and to show appreciation for the user's help was given an introduction, after a *Google Forms* link was sent to the user with the consent form where it explained that the answers will be anonymous, private and only for academic purpose and if he signs accepts to perform the test.

The initial survey was sent to have general knowledge about the demographic data and the knowledge the user had about the whales' relation to carbon dioxide.

##### 5.1.2 User First Interaction and Task

After fulfilling the two initial forms the user had the opportunity to explore all the functionalities of the

application with a maximum time of five minutes.

After we decided to ask the participant to navigate from the cover screen until the deadfall screen and let the video ends.

Following the task we were ready to get some qualitative data from a Retrospective Think Aloud once we asked the respondents to describe the steps of the task and after that the researcher showed the video recorded with the actions taken in the task to recall, express their line of thought and express what they felt. During this stage, the researcher added some important commentaries to a notebook.

##### 5.1.3 Final Debrief

The final debrief had the goal of assessing the usability of the experience with the application. Despite one "yes or no" question, all the others had an answer range that starts at 1 and goes until 5.

Finally we presented a test with three simple questions about the project to know if the visualizations and the texts were effective in transmitting the information.

### 5.2. Results

#### 5.2.1 Users' Characterization

Regarding the initial survey about demographic data, 27 people participated in our usability study, of which 21 of them were between 20 and 29 years old and the remaining 6 were from 30 to 65.

In terms of occupation, 10 respondents were students, 3 of them worked as well, 19 were employed and one was retired.

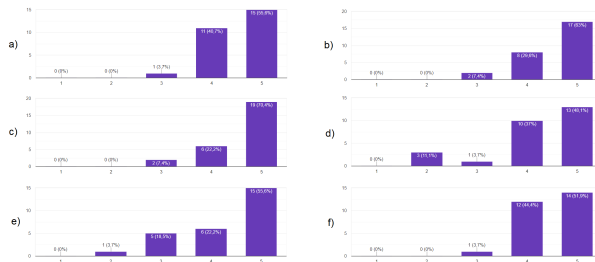
About the knowledge of the participants on the topic in question in the project, 51.9% knew about the role of whales in the balance of the marine ecosystem and only 18.5% knew about the role of whales in carbon absorption.

#### 5.2.2 Quantitative Analysis

Analyzing the visualizations, only one person answered *No* to the question *Do you think that the format of the visualizations – character and map/timeline – helped you to contextualize the information?* what makes us agree that the visualizations made the difference and were approved by the users in general.

Most parts of respondents rate the experience as interesting (11 of 27) and very interesting (15 of 27) and only 2 of 27 consider that the app has a medium intuitive flow, with these results we can assume that our project has a good level in terms of user experience.

About the creation of a persona, whale Dory and the videos shown with the whale as a protagonist we asked if the user empathized with Dory to which



**Figure 1:** Post usability survey result: a) How do you rate the experience?; b) How do you consider the App?; c) Has the experience made you aware of the problem?; d) Has the App aroused your curiosity about the influence of the oceans and whales in the fight against climate change?; e) Did you empathize with Dory?; f) Would you talk about the topic with friends or family with the aim of raising awareness?

15 replied that they strongly agreed, 6 that agreed, 5 that somewhat agreed and 1 disagreed.

19 of 27 participants answered that strongly agree that the app could raise awareness about the problem of the whales. 3 respondents of 27 disagreed when questioned about the capacity of the app to arouse curiosity about the influence of the oceans and whales in the fight against climate change, however 10 agreed and 13 strongly agreed. Of the 27 participants, 26 agreed or strongly agreed that would talk about the topic with friends or family to raise awareness.

In general, the results show that the goal of raising awareness about an unknown however important theme was achieved with success.

### 5.2.3 Knowledge Test Analysis

The first question was related to the graphics of the migration screen, where we asked between a tree and a whale who absorb more carbon and in this case only two participants were wrong.

Following we asked if the whales are a key player in the growth of Phytoplankton and 26 of 27 respondents got it right.

In the last question of the test, we decided to be a little more ambitious and find out who paid attention to the pump screen text asking what is the approximate percentage of Earth's  $O_2$  produced by Phytoplankton, 55.6% of the respondents pick the right answer of the three possible choices.

With these results we concluded that dynamic visual information like graphics and visualizations are more easily captured than text information.

### 5.2.4 Qualitative Analysis

8 of the 27 respondents claimed that the texts could be more complete and suggested the integration of links that redirect to pages related to the topic.

Another issue pointed out was the fact that the screen has visualizations, text and graphics that appear simultaneously and take the focus off the video, which can make the users not follow what the video has to show.

As positive points, 10 of the 27 participants highlighted the intuitiveness and simplicity of the general application, justified by saying that they understand everything that was being explained.

9 respondents referred that the videos have a good way to hold the attention making the application more interactive together with the dynamism transmitted by the graphics.

In short, most users supported the idea of the project being used in a museum or other public space and would be suitable for a younger audience.

### 5.3. Discussion

From the analysis of the usability tests we conclude that our application was well accepted by the users in terms of experience, dynamism and subject however we can improve some aspects. Thus we believe that we achieve our goals, developing a solution that can easily transmit the information we want in a way that makes people think and consequently learn a new subject to comment on with family and friends spreading the message.

### 6. Conclusions

The theme of carbon dioxide in the atmosphere and the fact that the amount of this gas does not stop growing should be at least frightening for everyone but even more for generations that will suffer a lot from it. It is upsetting that those young people, some of them who in a few years are going to be who will have the greatest influence on the future of the planet, are not aware that the present must be changed so that in the future they can live in a healthy world and deliver it as they found to the generations that succeed them.

Our value proposition consists of a one-time use platform that was developed to be succinct and interactive, focusing on the user's attention and the capability of him or her to retain all the information presented. The visualizations were fundamental pieces for the user not to get bored and made the user learn without realizing it.

This project besides the raising awareness about the advantages of the whales could evolve into an application that shows solutions and the users could take measures to help the whales and even have the perception of what their good actions imply through something that gives them the estimated numbers in terms of carbon dioxide captured.

Regarding the usability tests we could not use a large screen in a public space and this is also a

task for future work.

Taking in account the results from the usability tests we should have given more attention to information for those interested in understanding better how the carbon dioxide capture mechanism works, removed any kind of distractions from the 3D visualization and made the screens more immersive with ocean animations and add sounds.

In short, the expectation is that the application will reach as many people as possible whether in schools, museums or other public spaces such as metro and bus stations and in a small or large way it can improve the air we breathe.

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