

## Awareness of children about rational use of water: an approach basing on serious game

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**Abstract.** The water shortage expectation in a near future proves that the world population must be mobilized, as soon as possible, to face the problem of the water waste in daily activities. This paper presents the development of a web serious game to teach children about that problem which already affecting lives of many people around the world. We believe that education could be the better tool to change cultural habits and, in this way, the bigger awareness and a better use of hydric resources.

**Keywords:** serious games; web application; water; children; data mining.

### 1. Introduction

The planet Earth is usually called the “Blue Planet”. This fact occurs because much of its surface is covered with water. However, according to the International Water Agency (IWA, 2017), 97.5% of an entire water is salt, leaving only 2.5% of fresh water. Subtracting the water from rivers and lakes, in caves and frozen at the poles, leaves only 0.034% of the total water could be considered potable and within human reach. In addition, this water is not distributed well to population, and many countries have water crises. The water shortage expectation in a near future proves that the world population must be mobilized, as soon as possible, to face the problem of the water waste in daily activities.

In this way, the population must be awareness about the rational use of potable water. We believe that the education of children about this problem could transform them to a correctly use water that we consume.

According to Piaget, as children are in the formation their personality and development, they are more receptive to information than adults (PIAGET, 2000). Taking into account this problem, there is an urgent need to raise children awareness in the preservation of the important good. In the education area, serious games are used as tools to help in learning (BAKER, 2000), (HUIZINGA, 1971), because they motivate the students, facilitating their learning (DETERDING, CANOSSA, HARTEVELD, COOPER, NACKE, WHITSON, 2015).

This paper presents the development of a web serious game to teach children about that problem which is already affecting lives of many people around the world. We believe that education could be the better tool to change cultural habits and, in this way, the bigger awareness and a better use of hydric resources.

The paper presents the game development, the tests with children in fundamental school and the results obtained, based on questionnaires (qualitative analysis) and game database that were stored with children activities during the game tests with decision tree technique (quantitative analysis).

### 2. Theoretical and Technical Basis

#### 2.1 Serious Games

According to (RUCKENSTEIN, 1991), the game is part of the nature of the human being and it is essential for the reasoning, because playful elements are at the base of the

emergence and development of civilization. These authors define the game as: "a voluntary activity exercised within certain and certain limits of time and space, following rules freely allowed, but absolutely obligatory, endowed with an end in itself, accompanied by a feeling of tension and joy and an awareness of being different from everyday life".

Following this line of thinking, the technology industry grows, due to the great success of entertainment games and applications being used by everyone on their computers and mobile devices. In this way, opportunities also appear for serious games to arouse the interest of players (BAKER, 2000) (DETERDING, CANOSSA, HARTEVELD, COOPER, NACKE, WHITSON, 2015)(ARANHA, 2006).

Basically, the games are usually studied in four areas of human knowledge: the anthropological way, which studies the meaning and context of the games; the sociological way, which studies the effects of games on people (learning, cognitive development, aggressiveness, etc.); the technological way, that studies the elements that compose the games and analyzing their usage, as vectors of technological innovations; and the commercial way, which analyzes the creation, evolution and commercialization of games (ALLE, 1999). Therefore, games could be developed with different objectives, as (FIALHO, 2007), that works in the area of education, assert: "The game creates a fascination about people, who struggle for victory trying to understand their mechanisms, which constitutes a new way to students learn by playing".

Therefore, in a general perspective, Serious Games are software developed with the purpose of transmitting content of educational subject to the user or scientific purposes. The term "Serious" refers in this case to related products and situations in areas such as education, scientific exploration, health services, emergency management, urban planning, engineering, religion or politics (PRENSKY, 2003)(SAVI, 2008)(PERRY, TIMM, SILVESTRIM, SCHNAID, 2007).

## 2.2 Data Mining

Nowadays, technology advances at an accelerated level, requiring computational systems a high degree of data organization due to the large amount of such data. Therefore, new and more complex storage structures have been and are being developed, as: database, data warehouses and virtual libraries (CIOS, PEDRYCZ, SWINIARSKI, KURGAN, 2007)(HALL, 2009) (LAROSE, 2005).

According to (CABENA, 1998), from a database perspective, data mining is an interdisciplinary field linking knowledge machine techniques, pattern recognition, statistics, database and visualization, to be able to extract information from large databases. The main objectives of data mining practices are prediction and description. The prediction involves using some database variables or fields to predict future or unknown values of other variables of interest. The description focuses on finding patterns that describe the data and that can be analyzed by human beings. The objectives of prediction and description can be achieved using a variety of data mining methods (FAYYAD, PIATETSKY-SHAPIRO, ANDSMYTH, 1996). According these authors, an important data mining method of classification is the decision trees, which acts as a tree-shaped flowchart, where each node indicates a test on the value. This method has the objective of reducing to the maximum the impurity or uncertainty of the data (HALL, 2009).

This method was chosen in our work because it is easy to understand its results, and for presenting quantitative data basing the confusion matrix and the qualitative data basing

to graphical tree paths. Otherwise, it is considered a technique with good performance for large amounts of data.

### **2.3 Rational Use of Water**

About 70% of the land surface is covered by seas and oceans, the rest is occupied by continents and islands. It is estimated that 96.54% of the world's water is in the sea. There are also many salt lakes and it is assumed that more than half of the groundwater is also salted. Therefore, we can say that 97.5% of the water that exists is salty. Among the other 2.5% that is considered freshwater, 2/3 remain on the glaciers and permanent snow cover over the mountains and polar regions. And, the 1/3 that remains is confined in the pores or embedded in the fissures of the underground rocks, in formations known as aquifers (IWA, 2017).

Daily, we could think that we have abundant freshwater to use, but the distribution of these waters is far from homogeneous, with large amounts of water in the tropical jungles of the Amazon, the Congo and Borneo, and a huge variety of fauna and flora. On the other hand, in the Atacama, Gobi and Saara deserts, water is almost non-existent, with few species of plants and animals (CARDOSO, 2012)(MACHADO, 2002).

When discussing the reduction of excessive water consumption, it is common to find concepts and works of preservation of watersheds and the environment, as well as protection of fauna and flora. However, it is necessary to reduce household consumption of water, that is, to take measures that reduce the volume of water used in homes or reduce possible losses of water inside buildings.

The implementation of measures to save water in buildings provides a reduction in demand, thus creating a chain of hydrosanitary solutions. With the reuse and the use of water with conscience, it avoids overloads in the systems of water supply in the cities. Consequently, the required uptake of the water sources is reduced and, finally, a reduction of the sewage to be treated is achieved, which increases the treatment efficiency and reduces the pollution of the receiving bodies, decreasing the degradation of natural water resources and environmental systems (CARDOSO, 2012)(MACHADO, 2002).

In addition, there is still the economic advantage due to the reduction in the amounts of the invoices calculated on their consumption values. In economic aspects, it is also possible to take into account the reduction of costs in chemicals required for treatment in the Water Treatment Plants, used by the companies and the extension of the useful life of the elevators and water and sewage treatment plants. Extending its future expansions and avoiding new construction of hydraulic infrastructures (HAFNER, 2007)(FARIA, FARIA, 2004).

### **2.4 Used Technologies**

The web applications are software that could be used through any browser, being made available through a server. These applications are mostly embedded in Apache HTTP servers, which play the role of a web host, making it accessible to anyone with an internet connection. The most recent technologies used in these applications are HTML5, CSS3, JavaScript and MYSQL. The user uses the application with the request and response mechanism, where the browser sends the user's HTTP request and the server responds with HTML pages, images, PDF documents and data stored in the database (FOURNIER, 1999).

In general, they are constituted and developed in two stages: front-end and back-end. Front-end is the interface that is generated on the monitor of the user which is processed/compiled by the back-end, which communicates with the server through processes requested by the user through the front end, thus obtaining communication.

These applications, unlike the most current local programs/applications, web applications try to use the latest technologies to be a facilitator for access and compatibility, since they can be used independently of the operating system or browser, and the user does not have to install any new software on this computer. It also maintains compatibility with mobile phones and tablets, which are widely used today (PILGRIM, 2010)(RICCA, TONELLA, 2001).

### 3. Proposed Game

#### 3.1 Methodology

In order to develop the educational game for the awareness of the use of drinking water, we have defined a methodology that follows stages so that the game can be developed close to the actual consumption of water in homes. Figure 1 shows the methodology flowchart in stages. Firstly, a study and the acquisition of the flow of consumption of water in the residences was done, to obtain the volume of water that each of the main residential elements consume. With this, it was possible to begin the next step: to develop the game.

The game is a web application, so it can be to play on any computer with internet access, regardless of its operating system and browser used in schools. I was developed HTML, CSS3, Javascript and PHP and its platform being developed in HTML5, with the canvas graphic element, with the help of API Quintus, a game engine of Javascript that is widely used, because it facilitates the development of 2D games.

With the game developed, gameplay tests are performed. Firstly, with people involved in the project and consecutively with some students. In this way, it is possible to test and make final adjustments such as the functionalities, interactions and animations developed. After, we have tested in classrooms, with groups of students.

The last step is to extract possible rules of gameplay and analyze through questionnaires, if the children understood the purpose of the game, the subject addressed and also acquired some knowledge of the conscious use of drinking water available in their homes.

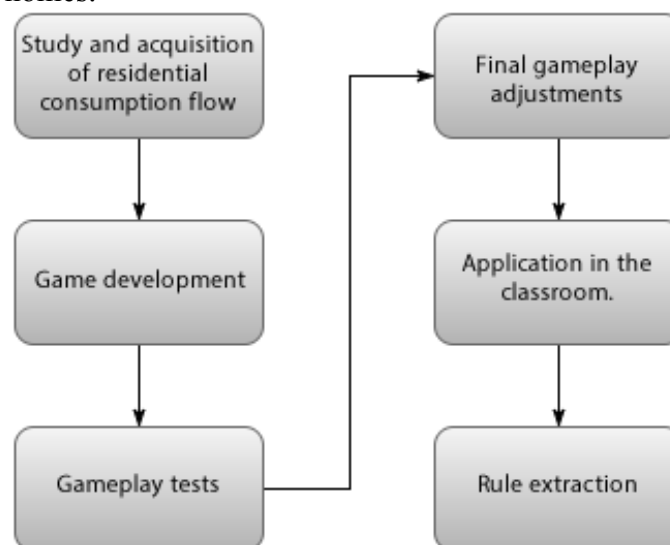


Figure 1 - Methodology flowchart

### 3.2 Gameplay

Throughout the study, the game's functionalities that can be observed through the skeleton of game, shown in Figure 2. Within the game, children will encounter real problems of non-water-conscious consumption, as faucets and showers poorly closed showers and people wash sidewalks and motor vehicles with excess water, in home environments like garden, bathroom and kitchen.

At the top of the game screen, there is a bar, which symbolizes the amount of water available for consumption. This bar will be reduced its value gradually, according to the flow of consumption of the elements that are being misused. It is an analogy of the “water is life”. To contain excess consumption, the child should contact the interface element and decides to solve or not the problem. As the child solves these excess consumptions, the water bar will take longer to completely empty. If the water comes to empty, the child loses the game and s/he starts all over again. Otherwise, s/he finishes this phase, s/he will move to other home environment (new phase).

Each environment will have some collectible items, as pipes, buckets, reservoirs and gutters. At the end of all the stages children will have the opportunity to assemble equipment that reuses rainwater and thus obtaining extra scores.

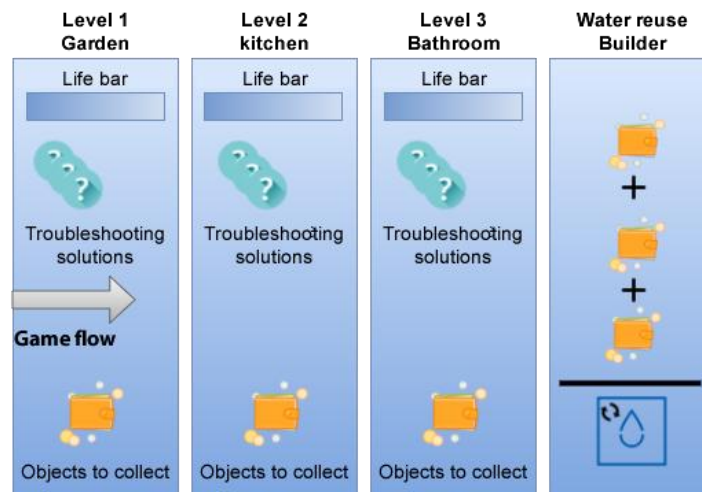


Figure 2 - The skeleton of gameplay

### 3.3 Graphical Interface and Mascot

As discussed in the theoretical basis, a serious game is not just for entertainment purposes, but it is necessary to look for ways to become enjoyable. Therefore, two mascots were created, as shown in Figure 3 and 4, to animate and represent the children within the game environment, also seeking some similarities in the subject addressed.



Figure 3 - Mascot 1



Figure 4 - Mascot 2

In order for the project to be online and accessible, a website was created. In this way, it is possible to access and disseminate the game, as well as contain information about the project as objectives, publications and results (<http://agua.starweb.org/>).

In Figure 5, the graphic interface of the game is presented. It follows the logic of the skeleton proposed in Figure 2: the player symbolized by the mascot; In the upper left corner the bar of life that symbolizes the amount of water still remaining; A gardener watering the garden with a hose, being a problem of waste of water to be solved by the player (one of the situations proposed in this phase of the game); And, a collectible watering can, which after the player takes, s/he could provide to the gardener, and changes the situation. During the phase, other objects are also collectible so that the player solves other problems, as well as set up an equipment for reuse of water at the end of the phases.

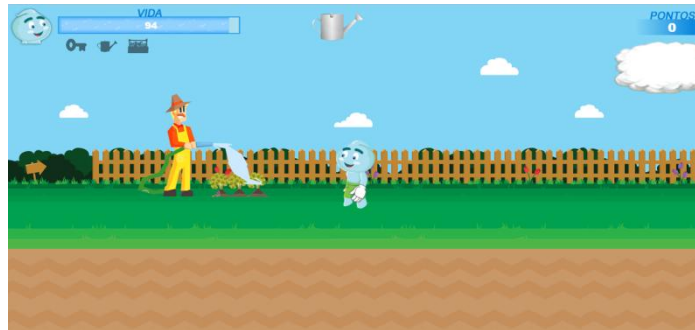


Figure 5 - Graphic interface of phase 1, which represents a garden

### 3.4 Database

In order for the game to be developed with quality and to obtain more robust versions and even better results, the database that will store the characteristics of the player is being implemented. Therefore, the database will have the structure of REM (Relationship-Entity Model), as shown in Figure 6, where we defined the following tables:

- Games: to save all games played. Therefore, it contains the difficulty selected by the player; whether the game was finalized; the points the player obtained; how many problems they solved in the game; how many problems they not solved; and when the game was created or modified;
- Moves: to save each player's action throughout the game. It contains if the player closes or opens a faucet or collecting an item. Therefore, the game ID; the phase that was played; the points in this game; the player's life; the ID of the object that was made

the action; the class of this object; the action performed on this object; if the player's intention was good or bad; and when this move was made or modified.

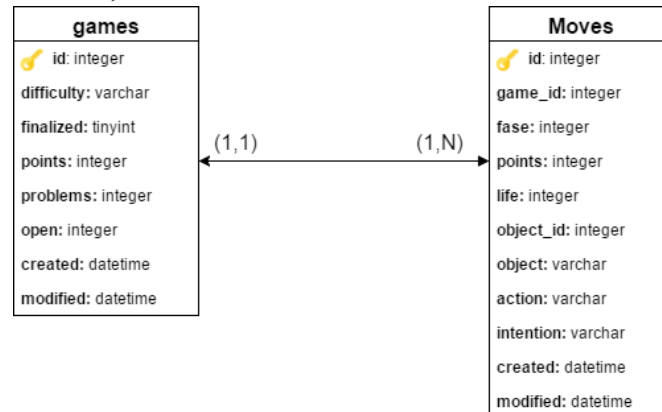


Figure 6 - REM of the game database

## 4. Results and Analysis

### 4.1 Mascot Names

Two weeks before the tests, a banner was left in the school, in order to promote the “election” of the names of the mascots. This banner illustrates the two mascots available in the game (Figure 3) and it was identified with numbers 1 and 2, since each child would have to vote for one name for each mascot. Next to the banner, a box was provided to serve as a ballot box, allowing the children put they votes in a anonymous way.

Of all the groups, 62 children voted and the choices were “MC Gotinha”, for number 1 and “MC Gotão” for number 2. In Brazil, the Funk music style is very famous, and the funk singers are called MCs. “Gotinha” means a little water drop and “Gotão” means a big water drop. Therefore, these names were used in references to mascots, both in the game environment and in the documentation of our project.

### 4.2 Pos-game Questionnaire

An online questionnaire was made available through Google Forms (in the game interface there is the link to access). The main idea is collected information from the children who play the game and the children answered after to play. In this way, it is possible to make improvements in the gameplay and to know if the project is reaching its goals. The questions presented on the questionnaire are:

1. Name, age and school level.
2. Do you like computer games?
3. Did you like the water game?
4. Did you experience any difficulty during the water game?
5. If yes, what is it?
6. Would you change anything in the game? What?
7. Would you use what you learned from the game at your home?
8. If no, why?
9. What do you think the water game wanted to teach you?

Questions 1, 5, 6, 8 and 9 are open (descriptive) questions. Questions 4 and 7 are Yes or No. Questions 2, 3 and 4 used the Likert Scale (Really enjoyed, Enjoyed, Indifferent, Like little, Not Like).

The first tests were carried out by the members of the project, to analyze if all features are correctly implemented.

The tests with students of the 4th year of elementary school of a public school at our city. About 40 students participated (three different classes), and their average age was 9 years-old. The class teacher ever time is presented to students. The children played for approximately 20 minutes and answered the questionnaire at the end of the tests.

About the pos-game questionnaires, the Figures 7 and 8, with the Likert of 1 to 5, where: 1 = Really enjoyed and 5 = Not Like, most answered that they like computer games a lot and that they liked the water game.

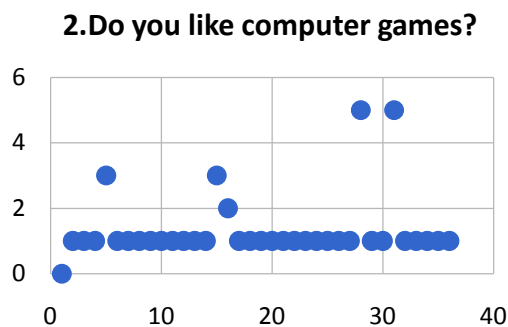


Figure 7 – Answers from questionnaire for question 2

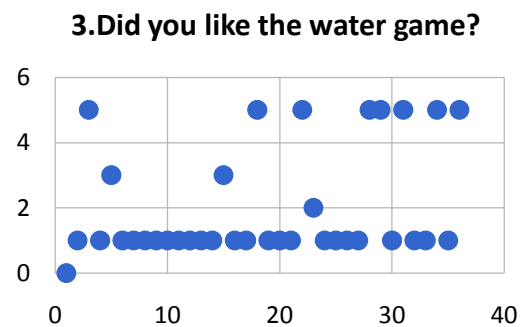


Figure 8 – Answers from questionnaire for question 3

When asked if they changed anything in the game (question 6), some students gave the following suggestions:

"I want kill someone";

"I did not like jumping in the clouds";

"The clothes";

"Turtles and little critters";

"I wanted to have a game for two people".

About the question 9, if the students understand about the main goal of the game, they gave the following answers:

"The game teaches me how to take care of the environment";

"Help the plants";

"Do not waste water".

We can conclude that they have understood the main idea of the game and help us to improve the game.

### 4.3 Data Mining Results

During the tests, 2,057 instances were acquired (1,767 from phase 1 and 290 from phase 2). In our first data mining, we have used the J48 algorithm J48 for Decision Trees technique in the software WEKA (WITTEN, FRANK, 2005), with its standard metrics and the chosen classifier attribute was the player's action (good or bad action during the game – the attribute "action" in table Moves of REM – Figure 5).

The correct classification of the technique was 100%, as shows that the database has solid data and the confusion matrix was obtained, according to Tables 1 and 2, indicating that there are not false-true values.



Table 1- Matix of confusion for phase of the tests performed

<b>Classification</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>
<b>A = start the game</b>	<b>39</b>	0	0	0	0	0
<b>B = collect an object</b>	0	<b>174</b>	0	0	0	0
<b>C = close an objetct</b>	0	0	<b>279</b>	0	0	0
<b>D = open an object</b>	0	0	0	<b>43</b>	0	0
<b>E = start the rain</b>	0	0	0	0	<b>33</b>	0
<b>F = finished the game</b>	0	0	0	0	0	<b>33</b>

Table 2 - Matrix of confusion for phase of the tests performed

<b>Classification</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>
<b>A = start the game</b>	<b>11</b>	0	0	0	0
<b>B = collect an object</b>	0	<b>25</b>	0	0	0
<b>C = close an objetct</b>	0	0	<b>48</b>	0	0
<b>D = open an object</b>	0	0	0	<b>9</b>	0
<b>E = finished the game</b>	0	0	0	0	<b>6</b>

## 5. Conclusions and Further Works

It is important to emphasize that this is a project still in progress and based on the results obtained it is possible to visualize that its progress presents coherent steps and with very promising results, either in the educational scope (serious game) or in the computational scope (data mining analysis).

We believe that with our tests, the game will help teachers in the classroom to put more emphasis on the subject addressed, which is of extreme relevance. The game was able to show, indirectly, children how to use freshwater in their daily lives and encouraging them to disseminate this idea to family and relatives.

As future work, we will perform more tests together with elementary school classes, as well as, with more instances in the database, to be able to perform the most complete and conscious data mining.

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