

# **AquaGuardians**

## ***A Tutorial-based Education Game for Population Engagement in Water Management***

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**Keywords:** Water Management, Tutorial Education, Serious Game, Alternate Reality, Cultural Representation, Community of Practices, Knowledge Management.

**Abstract:** Water management has mainly been dealt with by research institutions and governments with little engagement from schools, teachers and the population at large. This paper describes AQUAGUARDIANS (AG), an alternate reality, serious game for tutored education. The game offers a cultural environment to engage communities and, hopefully, crowds in water management by means of multimedia reading and writing experiences in virtual-real world scenarios. AG combines: a) gamified entertainment experiences; b) artistic production ‘cocompetitions’ of individual or collective cultural representations of water by multimedia communications; and, c) effective actions to save, preserve and monitor community water resources. Applications of AG in two cities suffering from severe water crises in Northeastern Brazil provide preliminary evidence the game improves (learning and water management) success indicators defined by schools and water management agencies.

## **1 INTRODUCTION**

Water is likely the only natural resource that is present in every aspect of human civilization, including in cultural or religious aspects (Organización Mundial de la Salud, 2006). In addition to an economic value, water has symbolic, spiritual, cultural, nourishing and public health values (Bordalo, 2008). Since 1970, water management challenges are becoming global (Castro, 2016), reflecting increasing awareness about uncertainties and problems. That is due to worsening conditions of the hydrosphere and to the unsustainability of water management practices in many regions, as well as conflicts and social inequalities that affect access to the resource. The origins of such uncertainties and problems are not technical nor “natural”, but instead, social and

political. The water crisis we face is caused by a mixture of (lack of) education and governance (Castro, 2016). According to the World Health Organization, one sixth of the world population live in “fragile states” with “weak governance and institutions” where a series of risks to humanity are due to poor governance in what concerns water in general, the management of rivers and other water sources, and to water and sewage utilities (Castro, 2016). The European Parliament and Council of The European Union in its matrices, directives and reports concluded that without a substantial improvement in water resource management and education, it will be very difficult to meet challenges such as providing sufficient food or sustainably generating energy for the world’s population (McKinsey, 2016). The challenge of water management has traditionally been addressed by

researchers and governments with insufficient engagement of schools, educators and the population at large. In order to reduce this governance crisis and to empower educational institutions to contribute, one needs a teaching-learning approach that connects the pedagogical practices at school with the day-to-day experiences and habits people have when using and caring (or not) for water. We believe reading-writing activities have a major role to play in addressing such water preservation and management challenges and problems.

According to the report from the Programme for International Students Assessment (PISA), 20% of 15-year-old students do not attain the baseline level of proficiency in reading in OECD (Organisation for Economic Co-operation and Development) countries. The same frail situation is also the case in Brazil, although the country has risen in the overall ranking for the last fifteen years (OECD, 2016). Such frailties denote the need for a social interactive perspective (Koch, 1992), where the concept of text extends beyond the frontiers of the oral and written (be it printed, graphical or conventional) components of the linguistic code.

One needs reading to take place within the context of communication practices which, when socially produced, involve a noticeable diversity of agents (or actors – i.e., those who execute an action) who interact in an unceasing and transforming exchange of information and of cultural representations of their world(s). The act of reading therefore, must be understood as a process or exercise on otherness where each other becomes a bridge to reach another, mediated by a meaningful, symbolically woven whole that is to be understood and interpreted to yield a new symbolic, undividable and meaningful reality - i.e., a new text which will in turn be decoded, understood and assigned a (new) meaning to generate another new text – in an unending repetition. This movement away from oneself, to enter a world that is not the reader's, paradoxically makes the reader closer to her/himself, taking hold of the other's (society's) world, making the reader sensitive to relations between what s/he reads and the possibility to transform local reality as well as a more encompassing world reality and also her or his inner reality - with respect to water in particular.

In this context, educators face at least 3 major barriers: a) a humbling feeling due to the quantity of new communication media brought about by the internet and the speed (groups of) students develop abilities in these new media; b) incapacity to tutor all students in classes of increasing sizes; and, c)

restrictions to monitor learning contextualization and applications of themes in general and water in special outside the classroom for students usually spend more time in places other than at school.

To engage the population in caring for water resources and to empower educators to lead and to play a major role in local innovative educational processes the big challenge is to create learning experiences that go beyond the gamification of online content about water as prescribed by so many authors (Global Water Forum, 2016). Castro (2016) argues that it is necessary to explore human behavior changing possibilities in the life game that water represents, making it possible for the player to live a hero's journey beyond the magical circle of educational games about water.

After a brief review of related work, this paper presents an alternate reality, tutorial-based educational game to engage communities in the caring for water resources. The paper also presents results of preliminary research on the usefulness of such a game as a methodological and technological platform to support public policies of water management agencies with effective participation of schools, educators and population.

## 2 RELATED WORK

Environmental management and water resources management in particular started to see paradigm changes in 2007 when it became clear that changes in water usage would be more effective with the engagement of the user population and not only by endorsement of technical recommendations by professional experts (McKinsey, 2016). Engagement of other stakeholders began to gain importance. In this direction, the system of Collaborative Governance appears to be appropriate for integrated management of natural resources since it adapts well to the complexity of ecological and social systems and emphasizes collaboration processes for educating several social stakeholders on informal agreement building based on legal and regulatory frameworks through formal and informal networking. (Pahl-Wostl, 2007).

In Brazil, the several conventional, online and mixed courses of the National Water Agency (Agência Nacional de Águas - ANA) fulfill the demand to train the population for such engagement but they are yet to reach stakeholders more comprehensively (ANA, 2016). There are also some initiatives around theatrical reading of multimedia texts to transform readers into actors. "Dramatic

Wednesdays” is an extension project of Literature and Scenic Arts at the University of Brasília where participants go from individual and silent reading to collective and shared reading using oral and body languages. The project promotes the collective and collaborative production and presentation of scenic readings of theatrical texts and the editing and publication of audiovisual and photographic material in the Web (<http://quartasdramaticas.blogspot.com.br/p/apoio.html>). During the scene magic cycle, when readers-spectators take part in the play, the expected result, as commented upon in Gomes (2012), is that “these readers act and reflect on the scenic reading towards transforming society.”

Reading in Scene (Leitura em Cena) is a project of the Federal University of Alagoas where reading the literary text is taken up as a performance activity by a sensorial understanding of the reading act through which the reader, in contact with the intended sensorial interactions embedded in the written word, experiences possibilities of education, transformation and reconfiguration of perceptions about him/herself and about the world (Oliveira, 2010). These projects however, do not address social actions coordinated with the support of games for education and preservation of water.

From Plato’s “Allegory of the Cave” and Jean-Jacques Rousseau’s “Emile, or on Education” to the Tutorial Education Program (PET) of the Brazilian Ministry of Education, through Oxford’s Education model centered on the leadership of small groups [GAVIN, 2007], “tutorial education” applies to attempts at a comprehensive education practice by which the trainee, who is considered to be a (future academic or life) educator in training, is coached to transcend her/his trainee status to that of a surrounding-world transformation citizen (FNDE, 2013). In this practice, an educator (tutor) leads a teaching-learning experiment with a small group in a given knowledge area through interdependent practices of knowledge-creation (research); sharing (teaching); and, application to problem solution in a collaboration setting where the school is included (extension). Groups with 10 or more students start to present difficulties for the educators-tutors since leading even a small crowd of students is practically impossible.

The knowledge management approach proposed by Nonaka and Takeuchi (1997) and adopted by many public and private organizations to this day, offers useful principles and concepts for water management involving small crowds lead by schools. The approach establishes that for a group

to become a knowledge-creating organization it must complete a “knowledge conversion spiral”. (The spiral converts tacit to tacit knowledge; explicit to explicit knowledge; from tacit to explicit; and, from explicit to tacit knowledge.) Knowledge management however, has not been widely used by educators as an innovation tool at school for education on water.

Based on Joseph Campbell’s hero’s journey (1949), games known as “serious games” have been used to promote engagement, training and to motivate the execution of tasks by means of fun and play (Castellani et al., 2013). These games use intrinsic incentives – like conquests, social responsibility and ability building – and extrinsic incentives – like points, proactive feedback and (game proficiency) levels – to maintain player’s interest in learning a given content and to motivate s/he to attain a desired flow level in the activities that may be proposed in the game story (Kankaanranta; Neittaanmki, 2008).

Massively multiplayer online games (MMOs) motivate crowds with missions that promote contact with concepts and contents, expanding the reach of books, but are usually confined to virtual world experiences (Delwiche, 2006). Work on alternate reality games aim to make the player cross borders of the magic circle of a game experience and bring the player to act in some useful way in the real world (Huizinga, 2014). Such games, as proposed by Jane McGonigal (2011) and Katie Salie and Eric Zimmerman (2003), explore day-do-day experiences and cultural settings. These works however, despite (or perhaps due to) breaking new ground in game research do not incorporate new teaching-learning management paradigms and tools for social entrepreneurship to engage society in water management and preservation. Other games address complex, important social problems – such as mosquito-borne diseases and child obesity (Barros et al, 2015), (UFCG, 2016) – but, as far as we know, have yet to address issues related to water, as the game to be presented next, AquaGuardians, does.

### 3 AquaGuardians

The tutorial-based educational game AquaGuardians (AG) is played on two complementary technological platforms that were adapted for the water theme. On the mobile platform, the students-players may georeference their actions using the GPS facility, register and upload multimedia files, report on their artistic production (reading and writing) missions in

the real world, play theme minigames and quizzes and commercialize their production in the integrated marketplace. On the Web platform educators-players and water agents-players may: assign missions to students in the virtual and real worlds; access a control panel to monitor the gaming experience; access a georeferenced information system to manage students activities and teaching-learning indicators; use pedagogical facilities to train players; and, be a part of a closed AG social network and connections to major open networks such as Facebook and Instagram.

Missions cover specific activities of tutorial-based education which are interdependent activities of leadership, research, teaching and extension for the creation of multimedia textual workpieces on the theme of water with social impact whose value is acknowledged by the game community. These workpieces come out of a knowledge management experience of a small group and are based on the reading of a multimedia document (text, audio, video ...) that deals with some theme related to water. The reader may add to the document, becoming its co-author. The missions require theatrical readings that are carried out in real life “theaters” the player lives in – home, school, etc. The reader-player must contextualize the contents and recreate the document (writing assignments). A set of missions defined by teachers and agents corresponds to an AG season. An AG season may be divided into several sub seasons in order to

contemplate the priorities in the school curricula and operating agendas and thus synchronize with cultural agendas of urban or rural settings players live in and to the water agencies agendas as well.

New workpieces or products may be put up for sale at AG’s marketplace. Players may use the virtual money they receive while playing or for accomplishing missions to buy goods or services at the marketplace or to exchange for real world goods or services at participating AG partners.

AG game dynamics happen in three theaters as illustrated in Figure 1. The first saying about water takes place in theater 1, Here, teachers and water agents act as tutorial-based education counselors modelling and creating on the mobile and web platforms the reading missions supported by multimedia seed-documents (books, HQs, video clips, poems and other virtual and real games, leaderboards, etc.). Readers-players “say” the multimedia document by executing reading and writing missions associated with the production of new multimedia workpieces by exploring theater resources specified in the missions and accessible in minigames, quizzes and AG internal social networks which are in turn, linked to external networks. A virtual world is thus created but which has real ties to home, school and the city or rural space where the player lives.

Theater 2 is represented by communities and that is where the second saying takes place – at home, school, out in the street, at institutions, at family



Figure 1: Spiral of AG tutorial-based education game to water knowledge conversion through three reading-playing

reunions, ... Squads of readers-players say the text to the public through missions in the real world, flash mobs, campaigns, individual and collective actions. The public also acts in the game when it shares its demands and it builds new knowledge on water by interacting with players. From such interactions, the player creates a new document (georeferenced text, audio, video) that brings new stories in itself about the public demands being met and the collaboratively built knowledge.

The third saying takes place in theater 3 – the school. The readers-players present the new document s/he did with help from the public. The new document is made available on the mobile platform so that at the end of the season (completed spiral), new readers-players may access it and start the (re)creation and innovation cycle anew by their own sayings. There should be a celebration: “my third saying changed me and my world”. A new spiral cycle starts where the readers and their groups reach a higher level of education and awareness and actions concerning water.

By visiting the three theaters - which are representative of the actors’ real world (internet of things, community and school) - under the leadership of a tutor who is a teacher or a student who inspires others, knowledge about water management and preservation is built by the readers-players in AG’s missions. This knowledge will be successively converted and intentionally articulated to become part of the knowledge base of each person in the tutorial-based education group (students and teachers who play the game) and of the organization which is the group itself (class or parts of class at school that form the community of water caring practices). The spiral starts again after being completed once (in different missions in the game), but at higher levels of group capacity, amplifying the application of knowledge on water to other areas of

society, including the creation of for- or not-for-profit enterprises which will promote social, environmental and cultural responsibility towards water. In these progressive cycles of tacit and explicit knowledge conversion and multiplication, the groups form other groups and multiply. To give meaning and create cultural value about water conservation, in addition to those already lauded in history, AG incorporates utopianism into its reference story and gameplay. Utopianism consists of a transforming attitude of the future from optimized, fictional or projected scenarios of research hypotheses or actions towards water and its relation to human beings and society (VIEIRA, 2011). In fact, as the utopian characters of More’s game of proactive numbers of Utopia (MORE, 1516), in AG’s three theaters the players read in the morning, afternoon and in the evening in different ways allowed for by AG’s transmedia facilities to build through utopianism, new possibilities concerning water by discovery, experimentation, creation and innovation.

Figures 2 and 3 shows some modules of AG’s two technological platforms (mobile app and web system). Prototypes for the georeferenced Web Information System and mobile app for Android were implemented around PostgreSQL, Laravel PHP framework and Unity technologies respectively.

Every action-situation experienced in theaters 1 and 2 may be automatically georeferenced on the local map (if a mission so requires) and can be seen in a Control Center (Web AG), where educator-players can follow missions of student-players and groups. In case a mission is being executed in a place with poor or no internet access, the result of the action may be temporarily stored in the cell phone memory for later upload to the Control Center. Teachers follow actions on their own devices and may validate workpieces and award the

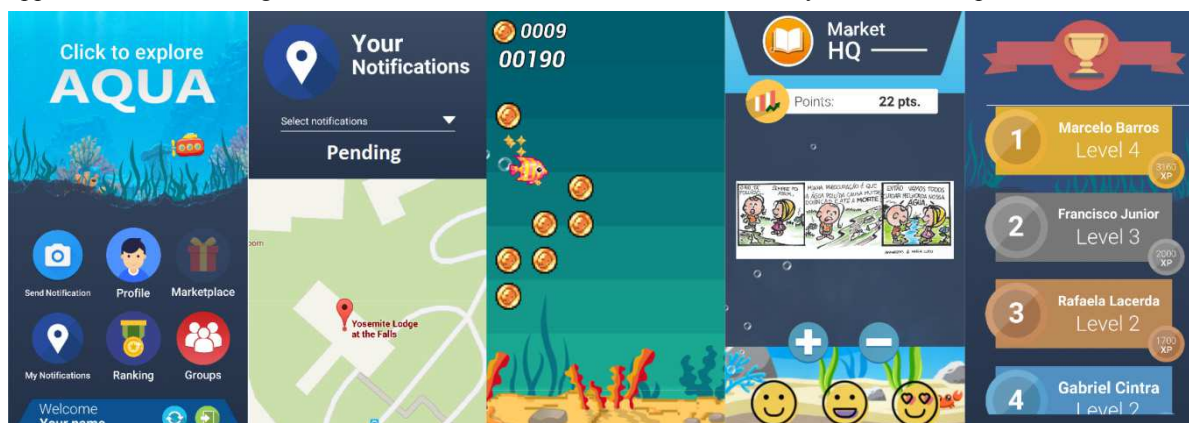


Figure 2: Some screens of AG game mobile platform.

student or her/his group for their production in the virtual (points and virtual money) and in the real world (grades, gifts, public recognition, etc.).

The mission dispatch facility (fig 3) is simple and intuitive to facilitate the work of teachers and empower them to innovate their pedagogical activities around themes and contents of different subjects by simply manipulating texts and buttons. Teachers may easily create a mission in which a student-player executes one or more tasks in the virtual or real worlds. Such tasks involve creativity in multimedia reading-writing, using an existing multimedia work (theme minigames, a quizz challenge, a leaderboard game or another digital game), or a challenge to go out to register an action of water wastage or saving or a combination of all that (a notification). In the mission, the teacher may also embed teaching-learning indicators and assign weights to work to be produced by the students according to objectives of the pedagogical process, and manage these indicators by means of graphs, statistics and reports that support continuing evaluation and planning of this process.

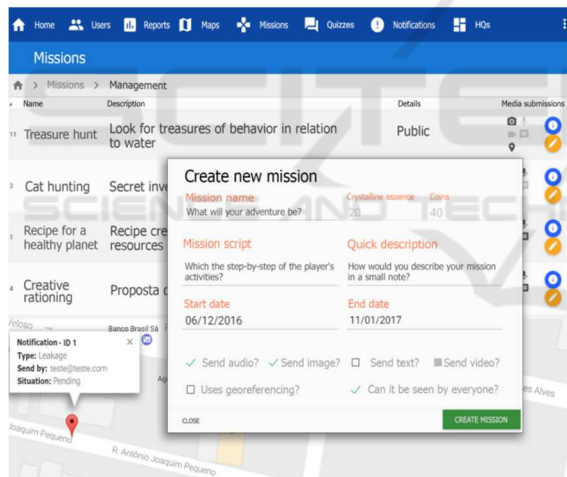


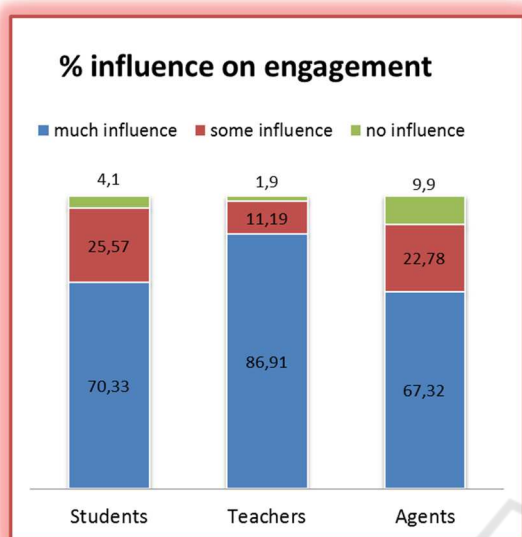
Figure 3: An interface to mission creation by teacher on the AG web georeferenced information platform.

## 4 CASE STUDY

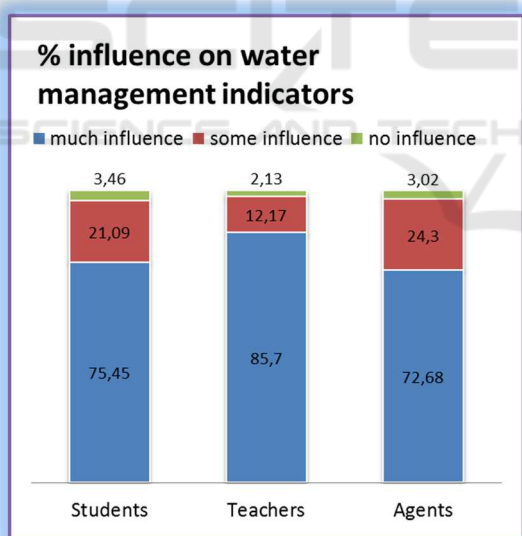
Preliminary studies based on the principles of experiment observer reliability (LITWIN, 1995), were carried out to verify whether (or not) AG would positively impact the success indicators defined by teachers and water agents and whether the integrated marketplace would indeed be an attractive facility to increase engagement of players and investors in the tutorial-based education service.

A validation experiment was performed with 232 users in September 2016. Of the total of users, 202 were students of the junior high and high school levels of city and state public schools in the municipalities of Sumé and Campina Grande in the state of Paraíba in Northeastern Brazil; 54,9% of the students were male and 45,1%, female; age ranged from 11 to 16 years old. Of the users, 17 were teachers at these schools with 23,5% and 76,5% being male and female, respectively; ages ranged from 29 to 50 years old. The remaining 13 users were professional agents belonging to a water utility - CAGEPA (Water and Sewage Company of Paraíba), and to a water management agency - AESA (State Water Management Agency), 52,1% being male and 47,9% female with ages ranging from 30 to 46 years old. All participants were trained to use AG's facilities and resources and played the game for a "season" of 3 weeks. Students were free to access minigames and quizzes and had to execute 4 real-world missions that were assigned by teachers and required the creation of texts, audios, video clips, toons and had to provide georeferenced examples of actions that lead to water preservation or wastage. After playing the game, each user was asked about the influence of AG's facilities and resources on engagement and on the strategic indicators by providing one of three possible answers: no influence, some influence and much influence. The considered indicators were: A) Influence of real-world missions on the number of volunteer water agents. B) Influence of reading and writing missions on reading and writing grades. C) Influence of minigames on grades for tests on water issues. D) Influence of quizzes on grades for tests on water issues. E) Influence of AG's marketplace for game sustainability and evolution. Teachers, besides evaluating these indicators, also considered the following indicators: F) Influence of mission creation and dispatch facilities on the facilitation of pedagogical work. G) Influence of content integration facilities on the facilitation of pedagogical work. Water agents, besides evaluating the previous indicators, also considered the following: H) Influence of AG on the facilitation of monitoring water resources management indicators. I) Influence of AG's water agency sector integration facilities on the facilitation of agents' work. J) Influence of AG on the reduction of the average response time to water problem notification. Graph 1 presents results of these user evaluations of influences on engagement and Graph 2 presents results of these user evaluations of influences on

learning outcomes and water management indicators.



Graph 1: Evaluation of players (students, teachers and agents) of the influence of AG on the motivation to play.



Graph 2: Evaluation of players (students, teachers and agents) of the influence of AG on the learning outcomes and water management indicators.

## 5 CONCLUSIONS

This paper presented an alternate reality, serious game, AquaGuardians (AG). AG was developed

considering tutorial-based education and innovative reading of any multimedia work to engage schools and the population at large in individual and collective actions for water management and preservation. Besides gamification techniques of conventional games that were used in AG's mobile app, the proposed game also offers a Web georeferenced information system for teachers and water management agents to create, dispatch and manage georeferenced missions for the players (individual or collective flash mobs) in the real world in addition to adventures in virtual worlds that explore principles of crowdsourcing, utopia, incentives engineering, knowledge management, trust verification, entrepreneurship and e-commerce. Results from preliminary, 3-month validation studies suggest that AG's facilities and resources motivate players to transcend their original roles as students, teachers and water agents towards the role of sector 2.5 social business entrepreneurs and positively influence success indicators defined by teachers and water agents. Experiments with longer term usage of AG are being organized to produce statistically more significant results.

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