A MODEL FOR UBIQUITOUS SERIOUS GAMES DEVELOPMENT FOCUSED ON PROBLEM BASED LEARNING

Sandro Oliveira Dorneles, Cristiano André da Costa and Sandro José Rigo
Programa de Pós-Graduação em Computação Aplicada (PIPCA), Universidade do Vale do Rio dos Sinos (UNISINOS)

ABSTRACT

The possibility of using serious games with problem-based learning opens up huge opportunities to connect the experiences of daily life of students with learning. In this context, this article presents a model for serious and ubiquitous games development, focusing on problem based learning methodology. The model allows teachers to create games based on problems. Besides, such games can be adapted to real-world scenarios, using context-aware information to enable interaction with real situations in that environment. The main scientific contribution of this work is related to teachers' autonomy, creating a motivating learning environment and fostering the relationship between theory and practice. To evaluate the model, we developed a use case, detailing the processes of game creation by the teacher, in an adaptive environment, and its use by the student. As a result, we expect greater student engagement in the proposed activities and to promote the development of higher order skills.

KEYWORDS

Problem-based learning, ontologies, serious games, ubiquitous computing.

1. INTRODUCTION

The spread of information and communication technologies is present and influences the social and professional life. Thus, there is no way to separate knowledge regarding Information and Communication Technologies (ICTs) from other areas of human knowledge. According to Carvalho (2011) "society and technology are inseparable phenomena and the changes that occur in one of them changes the other." This implies a new form of language and communication, which is perceptible nowadays in the consolidation of digital mediation, which must be applied to teach and learn. Holland and Holland (2014) reinforces that new technologies offer a great way to invigorate instruction, whether in traditional classrooms, online, or in blended learning environments.

As a result of this need, we observe an increasing use of methods to assist in the learning process, using the most assorted technologies. Thus, theories and learning methods that encourage and motivate students with the use of technologies gain strength, among them stand out the games and educational software (NETO and SOUZA, 2012).

The use of games to encourage motivation and assist in cognitive development is hardly a novelty (RIEBER, 1996), (GARRIS et al., 2002). However, the evolution and the combination of mobile and ubiquitous technologies allow expansion of the game into the real world (SEGATTO et al, 2008), (CHEN and HUANG, 2012), thus allowing space, time, and social relations to be part and interact with the rules of the game, permitting to expand student interaction with the object of study, regarding context aspects.

This article proposes a model for the development of serious games, called UCHALLENGE, fostering motivation in the field of education. This model uses ubiquitous resources as a way of interaction, thus enabling a real environment to be part and an extension for a playful learning. Associated with this technology, a pedagogical proposal is used, supported by the Problem Based Learning (PBL) methodology (BARROWS, 1980). With this, we hope to expand the autonomy of the student, through features and challenges, propose the construction of solutions to real or simulated problems, making them a motivator for learning, thus mobilizing different areas of knowledge.

The possibilities of expanding a game from the virtual to the real world, not only as a fun factor, but also with well-defined educational objectives, present new opportunities for interaction between knowing and doing. However, we are not referring to any game, but those that focus on learning purposes, the so-called serious games (CLARK, 1970; GIESSEN, 2015), whose main purpose is not only fun, but also training, simulation, marketing or education.

The expansion of the game into the real world is based on the possibilities of ubiquitous computing, as defined by Weiser (1991) and reinforced by Satyanarayanan (2001). The latter defines this concept as the "creation of environments saturated with computing and communication capabilities integrating them with users", allowing also the possibility to link and extend learning content with real situations of everyday life.

However, for this to be effective, it is important to create conducive conditions to the student in this autonomy process and search for knowledge. Therefore, we need to use learning methods that assist in the knowledge building, associated with information technology.

In the above-mentioned learning theories, which are presented to us, the question that arises is *how to find a conceptual and general epistemological model that incorporates technology to learning*? Several attempts of using educational games (SANCHES and OLIVARES, 2011), (NETO, 2012), (MORAN, 2012) have been tried as a proposal to assist in this process. However, some games end up emphasizing traditional repetition methods with a technological guise. Therefore, we must find ways to harness the motivation provided by the games to assist students in their knowledge building and autonomy, connecting the virtual and real world.

In this sense, the problem-based learning, hitherto restricted to specific segment of Medicine, has gained strength in schools, colleges and universities in different areas of learning (SAVERY, 2006). When using the problem based learning method, students are encouraged to think critically and they are given responsibility in building their knowledge (ÖZBIÇAKÇI, et al., 2012). Thus, learning is directed by the student in small groups, through problems, which are systematically resolved to achieve the intended educational goals, and seek autonomy, work, and cooperate in team skills.

Barrows (1980) points out that learning from problems is a condition of human existence and that learning occurs in our attempts to solve the many problems we face every day. Therefore, approaching and encouraging students through challenges in solving problems can significantly help in the process of learning autonomy. A serious game, using ubiquitous resources, can motivate and encourage the knowledge building, allowing for even more interaction between the student and the context, thus providing opportunities for more action in this process. According to Piaget (1967) cited by Clark (1974, p.11) "Intelligence is born of action, and anything is understood only to the extent that is reinvented."

Consequently, the goal of this work is to specify and evaluate a model for creating educational serious games that use resources of ubiquitous computing, using a methodology based on PBL. As a result, we expect the model to provide greater motivation for the student, thereby creating new learning opportunities. The main scientific contribution of this work is to enable the teacher to create a real learning environment that fosters the interaction between theory and practice.

This article is organized into five sections. Section two presents related works. Section three discusses the proposed model in details. A case study showing teacher and student role is presented in section four. Finally, we discuss the conclusions and directions for future work.

2. RELATED WORK

Several studies address serious games, using concepts of mobile and ubiquitous computing. As the target of this study, we selected models that jointly dealt with the issues and had, as main point, learning goals.

Huizinga (2008) points out that "every game is able at any time to fully absorb the player" setting for that social, temporal, and spatial aspects. The use of ubiquitous games creates the possibility of expanding these aspects, thus increasing the contractual magic circle of a game (MONTOLA, 2005), creating new social, spatial or temporal relations beyond the virtual world, facilitating the expansion to the real world. The authors also suggest ways and use of technologies for creating ubiquitous games for educational purposes.

Chang et al, (2009) presents an educational game, supported by mobile technologies. In the proposed model, they employ location, geographic information systems (GIS), and sensors such as Radio Frequency Identification (RFID), to develop a ubiquitous learning environment. The aim of the proposal is to improve

the students' participation in the planned activities, targeting to study a course whose learning area covers Taiwan culture.

Laine et al., (2010) reports studies performed within a period of three years by the team at the Ubiquelab from Eastern Finland University. The study discusses possible uses of technology in school, through a model for games based on pervasive learning spaces (Pervasive Learning Spaces - PLS). Experiments are laid out based on the development of ubiquitous games using a hipercontextualized design model, that is, "where the game is rooted in the same context in which the player is embedded" (LAINE et al., 2010).

Liu and Chu (2010) present the results of a game and its ubiquitous possibility targeting English learning, and also motivation in that regard. The model, called HELLO, integrates cameras and Quick Response Codes (QRcodes) tags distributed in the learning environment, allowing the student interaction in the available contexts.

Weatherlings (KLOPFER et al. 2012), is a collectible strategy game card, similar to several other games (Trading Card Games - TCG). In this game, the user assembles a custom deck, combining strategic battles, to play against other opponents. The deck is composed of weather creatures and the information available to students is composed of sources of weather data. The activity allows the interaction of students with real data regarding climate and weather. According to Klopfer et al. (2012), the game aims to provide users to "be able to read successfully weather tables to plan appropriate strategies to actual historical weather data."

Chen et al. (2012) presents a model and results of a Ubiquitous system called adventure game (RPG) learning system based on the game. The authors aim to improve the learning experience through ubiquitous games. Thus when students are doing the learning activities, the system will record the path of learning through GPS device, text files and progress. When the game ends, the system shows the learning progress and related content.

All models considered have some ubiquitous characteristics, which can be understood as "the coordination of intelligent devices, mobile and stationary, to provide users immediate, and universal access to information and new services transparently, to increase human capabilities" (SANTAELLA, 2013). Hence, considering these related works, one can consider that some aspects such as the method of learning and motivation from the real world to the virtual intersection can be better exploited.

The models presented do not allow the creation and adaptation of the game by the teacher and there is neither ontology that manages the steps of the proposed challenges, nor adaptation scenarios that can be used in different areas of knowledge.

3. PROPOSED MODEL

The proposed model, called UCHALLENGE, seeks to provide a possibility of creating serious games supported by the PBL methodology. In the proposal, the teacher can manage the game by setting the domain to be used, content, problems, and challenges that will be available at each stage of learning. Other characteristics that the teacher manages include the scenario and the ubiquitous resources that can be integrated in the context in which the game will take place.

UCHALLENGE is based on three aspects: ubiquitous computing (WEISER, 1991), (SATYANARAYANAN, 2001), serious games (CLARK, 1974), and problem-based learning (BARROWS, 1980). Thus, the following aspects take part of the model:

• to be adaptable to different domains, allowing the teacher to organize the game according to the area of interest;

• to allow the insertion and use of information: the teacher has the possibility to manage the database as needed, making use and reuse of existing data;

• to provide the creation of problems and challenges: to enable the teacher to develop problems and sub-problems and the challenges that will be part of each stage of the game;

• to provide environment information: to enable the teacher to generate challenges that can be adapted to the context, defining the points of interaction;

• to manage problems and challenges, so that the student can receive the challenges in each stage of the game and level of learning;

• to use an ontology, based on Bloom taxonomy (Bloom, 1956 apud Chan et al., 2009) and its cognitive objectives, providing challenges, content and problems according to context and development of the student, taking into account an increasing complexity;

• to store game results, including paths followed by the student during the game;

• to manage the game, enabling students to start a game or resume where it left off before;

• to support ubiquitous resources and contexts, including QRcode , RFID sensors and geolocation systems;

• to allow the interaction between users and teachers, providing communication between users to discuss and solve game challenges, as well as interventions and feedbacks;

• to foster social integration, enabling access to social networks for exchange and dissemination of information;

• to be attractive, fun and motivate the student, so that the user want to continue playing.

Figure 1 presents the UCHALLENGE model. Generally, the architecture is divided in two components: teacher and student modules.

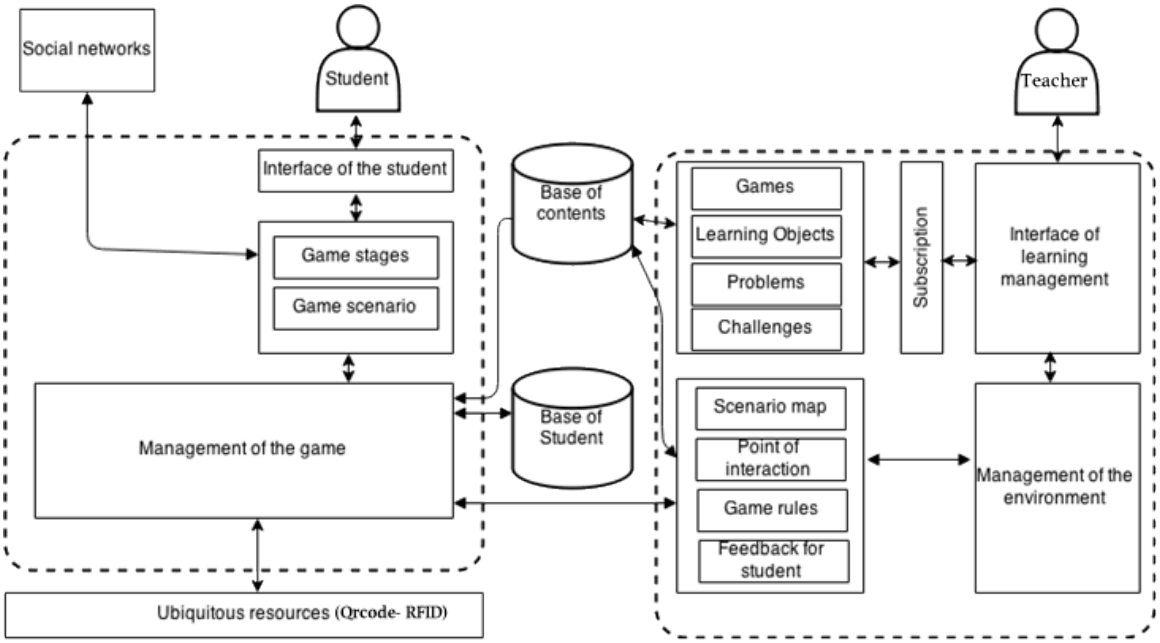

Figure 1. UCHALLENGE Model

The tutor module initially presents a learning management interface, in which teachers can access and manage the game, content, problems and challenges that will be used. Moreover, in the tutor module, the teacher can manage the map of the scene, defining the points of interaction and the rules of the game, as well as the feedback to students. The points of interaction and environmental challenges are defined on the map of the scene and converted to sensors that will be distributed, as defined by the tutor.

The student module displays the home interface, wherein the available games are displayed. When selecting the game, students receive the first step, or, if they had already started, obtain the corresponding step, and the scenario with the possible points of interaction. The management of the game controls the rules, history, access to the base of the student and content, besides enabling the use of ubiquitous resources available, as geographical location in relation to the scenario, communication with the available sensors and points of interaction.

The selection of challenges and problems offered to the student, are defined using an ontology, as in Figure 2. The ontology is based on the educational objectives defined by the teacher, from the cognitive processes established by Bloom (1956) and reinforced by Chan et al., (2009). Thus, levels of increasing difficulty will be presented to the student representing an evolution in their learning processes.

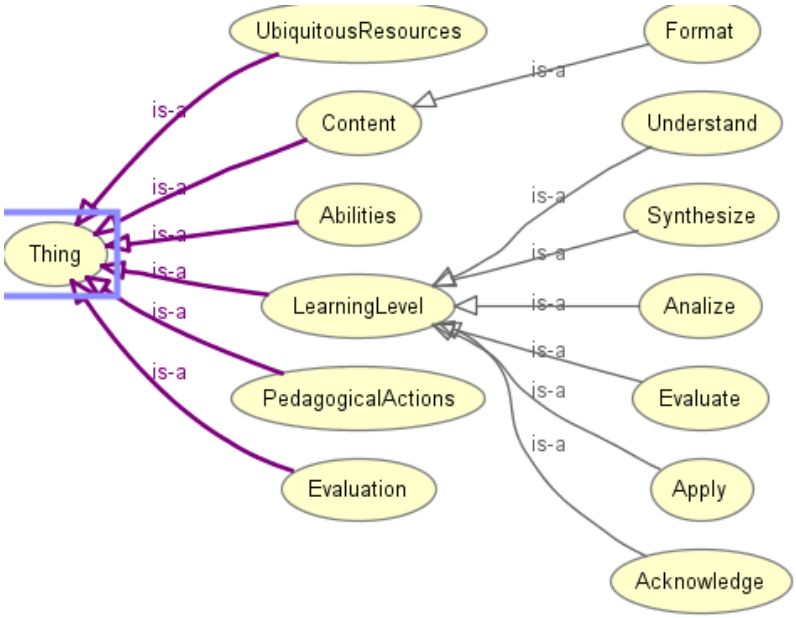

Figure 2. Relationship of the main classes of the ontology

4. CASE STUDY

To evaluate the UCHALLENGE model, we developed a case study to analyze usage scenarios in relation to the teacher and the student interaction. The scientific community has been using scenarios to evaluate mobile and ubiquitous computing projects (DEY, 2001; SATYANARAYANAN, 2001 and SATYANARAYANAN, 2011). Therefore, we proposed a scenario for a lesson in a History course. This scenario was evaluated with a developed prototype. The teacher's web interface has been developed in PHP language and Javascript using MYSQL database. For the student interface, we used the Android platform and developed an application using HTML5.

A History teacher has been teaching Global History, particularly Middle Ages, with the class. Upon bringing the subject on the early 11th Century, comes the need for students to make reflections on what aspects led to the Crusades and how it is possible for them to relate this concept to the present day. In order to encourage students to better learn the historic facts regarding the Crusades, the teacher will make use of UCHALLENGE to build a game set in a park, which simulates medieval forests. With the access to the server through the Web, the teacher logs on into the learning management interface.

In this interface information concerning the game are defined, such as: Area of knowledge: "Human Sciences"; Assessment area: "History"; Theme and the game: “Crusades”. The teacher defines the game scenario, from a map, which obtains the geographic coordinates of the specific park (Figure 3). The student then loads this piece of information. The teacher also registers the main problem to be solved: *Why was the Holy Land the cause of many conflicts between Muslims and Christians? This conflict still exists today?*

In the UCHALLENGE environment, the teacher registers also learning objects that will be available to the student’s research, as well as, problems and challenges. By registering the problems, the teacher needs also to define sub problems to be presented to the students in different stages of the game, as the following example:

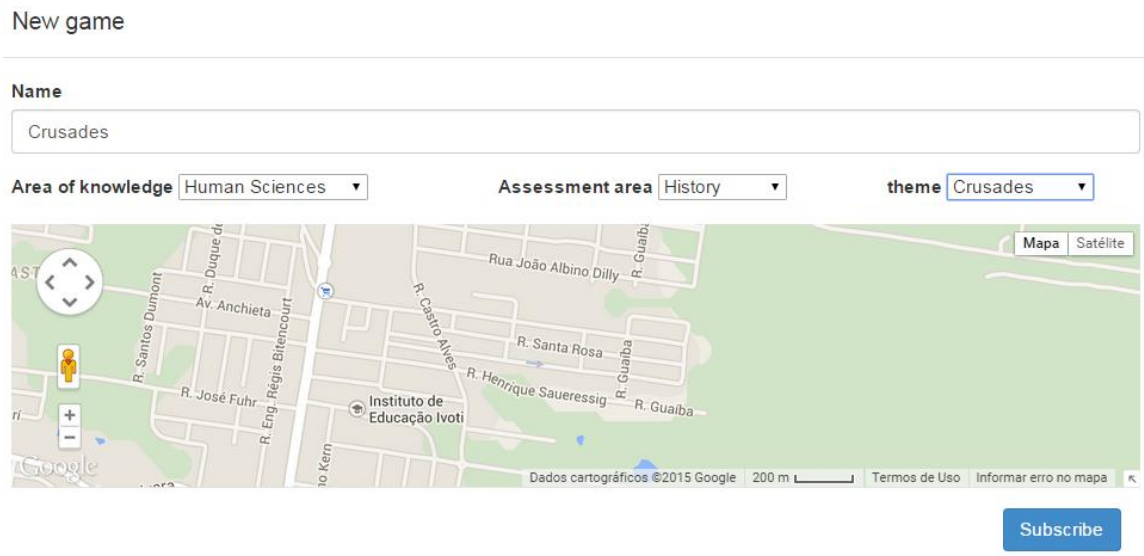

Figure 3. New game development: Selecting the place

- What happened between 11th and 13th Centuries in Europe?
- Do you know what the Crusades were?
- What were the reasons that led to the formation of the First Crusade?
- Which countries were involved in the battles and what were their real objectives?
- Which issues are still reasons for dispute today?

The contents, problems and challenges available are uploaded from the content base, in which they are identified by area of knowledge, assessment area, subject and pedagogical goals, so that they may be inferred by the ontology and presented to the student as the progress of the game.

Teachers prepare the environment of the game, selecting through a specific tool, the map coordinates with the game scenario information. In this defined scenario, the teacher will use QRCode and RFID sensors to create points of interaction with the player. These sensors contain specific clues to solve the problems or challenges during interaction with the context. The created points of interaction are displayed on the map of the environment and loaded later, from the player's position. After finishing the game settings, the teacher physically makes the sensors available in the game scenario, releasing the environment for students.

The student will have to register in advance in the system, after authentication (Figure 4a) the new games or the games in progress will be showed. After the game selection, students can access information about other players who are in the same game and may interact to each other to solve challenges or proposed problems. The interaction may be through messages or contact through social networks, if there is such a possibility.

The student, after registering, connects with the online server via a mobile device, which shows the available games (Figure 4b). Once the game starts, the student receives the main question, as well as a number of small problems on the subject (Figure 4c). The path chosen by the student, within the proposed scenario, will define what challenges and problems will be offered. The game map (Figure 4d) presents its geographical position in the scenario and possible interactions. Upon arriving at the point of interaction, the student drives the marker, thus, the QRcode reader in the mobile App is enabled to capture the information available on the tag. Such information may have practical or theoretical challenges to be solved in the environment. Consequently, the result of the challenge ensures to the student points or important tips for the next steps. At any time of the game, one student can share information with the others, through messages related to the challenges posed.

The teacher defines the rules of access to learning objects. They may be, for example, objects in text or multimedia format accessed freely for consultation. Alternatively, its is possible to specify that some content costs a number of knowledge coins, which are acquired through the solution of a Quiz, challenges, or extra missions that are presented in the game scenario.

(a) (b) (c) (d)

Figure 4. Initial Player Screens

In addition to the knowledge coins, the player also receives a score for each correct answer. Each time the student reaches 100 points, it can answer the problem proposed to that step, enabling the student to move to the next level.

The problems and challenges presented to the student are inferred in the ontology, through pedagogical objectives previously registered by the teacher, based on Bloom taxonomy of increasing complexity. After passing through all steps in the scenario, the student must still solve the main problem. The student may make use of the knowledge and experiences acquired during the game to present a possible solution that will be evaluated by the teacher.

At the end of the game, the student receives feedback from the teacher and share experiences and doubts, enabling new reflections on the working theme and analysis of the results obtained. From these results, the teacher may decide to review a subject or to create new possibilities to work with the class.

5. CONCLUSION

The UCHALLENGE has shown to be a viable option for building serious and ubiquitous games focusing on problem-based learning. The main advantage of the model is the real possibility of motivation of a student for a type of learning able to mobilize a set of cognitive resources and apply different knowledge using Problem Based Learning.

The proposed model presents, as the major scientific contribution, the viability of adapting different scenarios and areas of knowledge in a proposal of reflection on theory and practice by the means of solving problems. Unlike this proposal, the related works considered for this paper focus on specific approaches and with limited use of ubiquitous resources. A case study showed the viability of the model for preparing a class combining the real and virtual world.

As future work, we intend to review the creation of the game in a pedagogical perspective and the usability in different areas of knowledge. Besides the evaluation of the student in a real scenario, we plan to analyze aspects of motivation and engagement in the activities proposed, as well as its reflection in the students learning.

REFERENCES

Barrows, H. S. 1980. *Problem-based learning: An approach to medical education*. Springer Publishing Company. New York, USA.

Carvalho, M. G. D. 2011. Tecnologia, desenvolvimento social e educação tecnológica. *Revista Educação & Tecnologia*, No 1.

Chang, W. C. et al, 2009. Game-based learning with ubiquitous technologies. *Internet Computing*, IEEE, vol. 13, No. 4, pp. 26-33,

Chen, J. H. et al, 2012. To develop the ubiquitous adventure RPG (role play game) game-based learning system. In*Systems, Man, and Cybernetics, IEEE International Conference on.* Seoul, Corea, pp. 2973-2978.

Clark C. *Jogos simulados: estratégia e tomada de decisão.* J. Olympio, Rio de Janeiro, Br.

Dey, A. K. 2001. Understanding and using context. *Personal and ubiquitous computing*, vol. 5, No. 1, pp. 4-7.

Garris, Rosemary. Et al, 2002. Games, motivation, and learning: A research and practice model. *Simulation & gaming*, Vol. 33, No. 4, pp. 441-467.

Giessen, H. W. 2015. "Serious Games Effects: An Overview." *Procedia-Social and Behavioral Sciences*, Vol. 174, pp. 2240-2244.

Holland, J., & Holland, J. 2014. "Implications of shifting technology in education." *TechTrends* Vol. 58, No. 3, pp. 16-25.

Huizinga, Johan. 2008. *Home ludens: o jogo como elemento de cultura*. Perspectiva, São Paulo, Br.

Klopfer, Eric et al, 2012. Ubiquitous games for learning (UbiqGames): Weatherlings, a worked example. *Journal of Computer Assisted Learning*, Vol. 28, No. 5, pp. 465-476.

Laine, Teemu Henrikki et al, 2010. Critical factors for technology integration in game-based pervasive learning spaces. *Learning Technologies, IEEE Transactions on*, Vol. 3, No. 4, pp. 294-306.

Liu, Tsung-Yu and CHU, Yu-Ling. 2010. Using ubiquitous games in an English listening and speaking course: Impact on learning outcomes and motivation.*Computers & Education*, Vol. 55, No. 2, pp. 630-643.

Montola, M. 2005. Exploring the edge of the magic circle: Defining pervasive games. *In Proceedings of DAC*, Vol. 1966, pp. 103.

Moran, J. M. et al, 2012. *Novas Tecnologias e mediação pedagógica***.** Papirus, Campinas, SP, Br.

Neto, J. F. B. and Da Fonseca, F. S. 2013. Jogos educativos em dispositivos móveis como auxílio ao ensino da matemática. *RENOTE*, Vol. 11, No. 1.

Neto, J. F., & Souza, F. D. F. D. O. 2012. *Uma Metodologia de Desenvolvimento de Jogos Educativos em Dispositivos Móveis para Ambientes Virtuais de Aprendizagem*. UFPE, Recife, Br.

Özbiçakçi, Ş. et al, 2012. Assessment of goals in problem-based learning. *Nurse education today*, Vol. 32, No. 8, pp. e79-e82.

Rieber, L. 1996 Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational technology research and development*, Vol. 44, No. 2, pp. 43-58.

Sánchez, J., & Olivares, R. 2011. Problem solving and collaboration using mobile serious games. *Computers & Education*, Vol. *57, No.* 3, pp.1943-1952.

Santaella, L. 2013. *Comunicação ubíqua: repercussões na cultura e na educação*. Ed. Paulus, São Paulo, Br.

Satyanarayanan, M. 2001. Pervasive computing: Vision and challenges.*Personal Communications, IEEE*, Vol.*8, No.* 4, pp, 10-17.

Satyanarayanan, M. 2011. Mobile computing: the next decade.*ACM SIGMOBILE Mobile Computing and Communications Review*, Vol.15 No. 2, pp 2-10.

Savery, J. R. 2006. Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-based Learning*, Vol.1, No. 1, p. 3.

Segatto, W. et al, 2008 Mobio threat: A mobile game based on the integration of wireless technologies. *Computers in Entertainment (CIE)*, Vol. 6, No. 3, p. 39.

Weisser, M. 1991. The computer for the twenty-first century. *Scientific American*, Vol. *265*, No. 3, pp, 94-104.