GEOESPACOMOB – PLAYING AND LEARNING SPATIAL GEOMETRY USING MOBILE PHONES

Reginaldo Tavares Filho[1], Liliane Santos Machado [2], Ronei Marcos de Moraes[3], Rogéria Gaudencio do Rego[4]

Abstract — *Three-dimensional (3D) graphics have been an important feature to applications that propose to offer better experience and immersion to their users. Games that uses the 3D explore mainly the attractively that the immersion can provide. The use of 3D in mobile phones is recent and still involves some troubles of performance and usability. In this paper, the process of developing 3D graphical applications for mobile phone is discussed focus in an educational game implementation: GeoEspaçoMob. It is an educational game for mobile phones that intends to help students to identify forms in three-dimensional objects and fix concepts related to spatial geometry. Due to its design, GeoEspaçoMob requires the use of 3D graphical interaction and demands the exploration of the most recent graphical technologies for the new generation of mobile phones.*

Index Terms — educational games, mobile, mobile games, educational games for mobile

INTRODUCTION

Games have born from the need of the mankind to develop activities that give them some pleasure. This necessity can be observed through the history where each different culture has created its own game. So, according to many authors, the games are a kind of cultural product [1, 13].

Once games are considered as cultural objects, they also absorb the characteristics of the society in which they have been produced and used. Then, games that have been produced in recent years have acquired some facets of recent technological advances. Considering the current technologies and computational aspects, sophisticated techniques have been studied to improve the quality of the games. Some of the technologies that are conducting researches are algorithms analysis, computer graphics, network and artificial intelligence [1].

Since the graphic research has started, games have been one of the main target applications of their results. This fact puts the games companies as the leaders in such investigations [5]. It is important to say that these researches grow parallel with the financial return to the game industry. The main goal of a game is to be fun, to entertain users and attract the largest possible number of players. According to human anatomists and physiologists, the vision is the most used sense and must be the first one to attract the attention when developing a game [9, 14]. In fact, Clua et al (2002) interviewed 80 young people from Rio de Janeiro, Brazil, with age between 10 and 17 years old to know the main reasons that attract them to play a game. The results showed that most of the players considered that the most important aspects in a game are three: the challenge, the game plot and the graphic quality. Thus, investments in such features are important to the game industry [4].

3D graphics techniques can provide some features to the games like interactivity in real time with the world of the game. The interactive interface is the component responsible for connecting the player to the game, always showing the current status of the game scene. A good interface is the one able to involve the player, making him completely immerse in the plot of the game. Therefore, to design a good interface artistic, cognitive and technical aspects must be considered. The artistic goal of an interface is to please and attract the user. Cognitively, it is necessary to consider that the user will interpret such interface and this interpretation must fit in the goal of the game. The technical level of an interface is related to its performance, its portability, its graphics complexity, among other points [2, 6, 7, 11].

In the case of mobile phones, the requirements for use of three-dimensional interfaces will not be different. Technically, it demands a different treatment from interfaces for bi-dimensional applications. The evolution of the graphic quality at mobile phones depends on the solution of graphics rendering troubles and of usability and performance problems [3].

According to Bievenue (1995), the use of games to support educational practices received an upgrade with computers use. Mayo (2007) cites several advantages of using games as a facilitator of learning. Among those advantages is known that a game can help to consolidate the concepts taught in the classroom through a more motivating way. It also can facilitate the process of learning more comples concepts, can allow an active participation of students, can training them to be able to make decisions and observe their consequences. It also can help the teacher to diagnose some mistakes of learning and attitudes and difficulties of students. According to Koivisto (2006),

1 Reginaldo Tavares Virgínio Filho, Universidade Federal da Paraíba, LabTEVE, Cidade Universitária s/n, João Pessoa, PB, Brazil, regisfilho@gmail.com
2 Liliane dos Santos Machado, Universidade Federal da Paraíba, LabTEVE, Cidade Universitária s/n, João Pessoa, PB, Brazil, liliane@di.ufpb.br
3 Ronei Marcos de Moraes, Universidade Federal da Paraíba, LabTEVE, Cidade Universitária s/n, João Pessoa, PB, Brazil, ronei@de.ufpb.br
4 Rogéria Gaudencio do Rêgo, Universidade Federal da Paraíba, LEPAC, Cidade Universitária s/n, João Pessoa, PB, Brazil, rogeria@mat.ufpb.br

stimulus and interactivity are important conditions to the learning of school contents.

This paper presents the GeoEspaçoMob, an educational games that explores the mobility feature of mobile phones to allow a large use of the game by the students, not restricting them to fixed locations. It also uses the recent graphic technologies for mobile devices related to presentation and interaction with three-dimensional content to help the learning of spatial geometry. The target audience of the game are the students with age between nine and twelve years.

THE GAME

The geoespaço is a resource for the teaching of Euclidian geometry concepts, which mainly focuses on associate the scholar content of three-dimensional elements or spatial elements. It was created by members from Studies and Research of Scientific Learning Laboratory (LEPAC) of the Federal University of Paraiba (UFPB). The geoespaço is related of the use of concrete materials in the teaching of mathematics as a new form to develop the content of spatial geometry in the classroom, combining the traditional educational practice with the motivation provided by the fun of the games. The game is composed by two parallel boards, as shown in Figure 1, generally made with wood. In these boards are inserted pins or hooks that can be connected with elastic bands. The set of elastics connects hooks and forms a spatial object whose properties can be observed manipulating the boards.

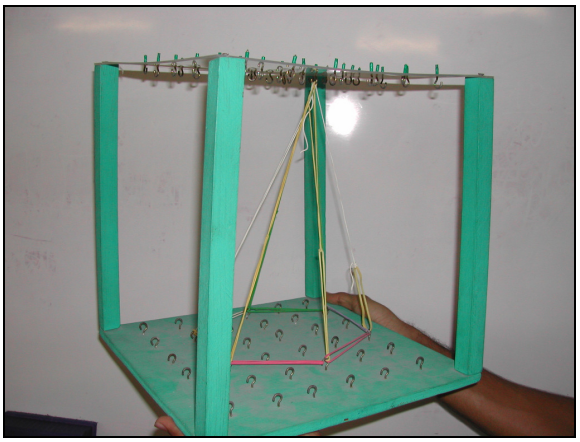

FIGURE. 1
THE GEOESPAÇO DEVELOPED AT LEPAC, UFPB

The geoespaco is based on the idea of a game that already exists which one of its goals is to work the flat geometry: the geoplano. Developed in 1952 by the Egyptian mathematician and educator Dr. Caleb Gattegno, the geoplano emerged as a teaching tool to build the concepts of geometry flat, the concepts of fractions, proportion and symmetry, among others.

GeoEspaçoMob

The proposal of geoespaço for mobile intends to facilitate the construction of the spatial geometry concepts among students from the first years of school. The main idea is to use the game to mature the recognition of objects, the concepts of this area of geometry and the rationalization of their properties. So it is an educational game for children between nine and twelve years old. Thus, this research presents a study on the production of entertainment and educational applications for mobile devices that explores the potential manipulation of 3D graphics. In this case, is presented an educational game whose content needs the specific support of this kind of graphics and its manipulation.

The game presented is called GeoEspaçoMob and intend to attract students for gaming and use the knowledge learned in the classroom to win. Extra information, that the students could need to advance in the game, will be transmitted by the game as tips or definitios. The GeoEspaçoMob Adventure game is an implementation of the geoespaço for mobile. In order to make the game attractive, the challenges of geoespaço are implemented in the context of a clues game. The scenario was designed to include the challenges in a three dimensional first person game. It demanded a good definition of a plot.

ANALYSIS AND DESIGN OF THE GAME

The phase of analysis and design of GeoEspaçoMob will be explained in the following way: in the first moment the plot of the game will be shown and the main points observed in the process of creation. Then the challenges script will be described. Finally, aspects of modelling will be shown and will allow to demonstrate the importance the two first steps in the game development.

The Plot

The plot is an important component of a game. It defines its story and, mainly, its goals. The differential of a game must be shown through this component that can make the game attractive or not. Particularlly, creating a plot is not a simple process for educational games. It demands not only creativity, but also the participation of educators of the subject of the game [6,8,10]. In an educational game there must be additional care about the plot of the game. It must stimulate the player to do right things and look for solutions when a doubt occurs. It also must avoid violence, death or some other content that may distract the student from the educational focus.

The story of GeoEspaçoMob has as environment an old public library that is frequented by a student, which represents the player. As he is a good student, he is in the library to study to a Geometry exam. But, when he entered in the hall of the library, he found a newspaper over a table with a headline that attracts his attention: “Thieves of rarity

attack again!". According to the newspaper, the police suspects, based on an investigation, that the next target of the thieves would be that library, where they will look for a mysterious rarity. After have read the article, the player must begin an investigation at the library, finding some clues there about a supposed book written by Leonardo da Vince with studies and very important discoveries about humanity. Although, there aren't more known details about the book and nobody knows exactly were it is in the library. Then, the student decides to find the book before the thieves. The student found a set of secret passages and corridors but will need to solve problems to open them. Those problems are related to spatial geometry and will demand three-dimensional visualization.

The secret corridors are divided into nine rooms with a progressive access, which have inside them colored cubes representing the geoespaço board. When the cubes are found, the library environment changes to a board with a challenge to the student. Solved the challenge the student goes back to the library environment. The rooms presents the follow design:

- At the first room, the player must find the cube of geoespaço. If he solve it, he will win special glasses.
- At the second room, the geoespaço will be floating and rotating and the player should reach it. Solving the geoespaço, the player will win a jetpack.
- At the third room, the player will only see the right cube if he use the glasses, otherwise he would see the cube that open the door for the seventh room, which doesn't have any geoespaço cube and whose exit door depends on an challenge from the sixth room.
- At the fourth room there will be several geoespaço cubes, but using the glasses the player will find the right one and open the next room door.
- At the fifth room the geoespaço will be next to the roof, and the player will nedd to use his jetpack to reach it and open next room door.
- At the sixth room, the geoespaço will appear and disappear at the corners of the room, so the player must understand this movement and reach the geoespaço at a corner.
- At the seventh room there isn't any geoespaço cube, the player must only find out the secret door.
- At the eighth room, the player will find several cubes, with or without the glasses, but only one is the real geoespaço cube. Solving the challenge, he will win a key to open the last door.
- At ninth room, the player will find the book, saving it from the thieves and give it to the authorities.

The Challenges Scrip

At the first phases of the development process of the game the main concern was the mathematics content. At the beginning it was necessary to know the geoespaço and what kind of association the board allowed to be make with the geometry contents. As there isn't any literature available that lists some possible ideas of games using the geoespaçoto help with the selection process of challenges, it was used the list of possible challenges of geoplano and adapted them to the geoespaço context. This phase also counts on the help of maths educators and researches of LEPAC, UFPB.

The part of the game that represents the Geoespaço with the challenges, demands the representation of three-dimensional space. This part depends on the real-time interaction of the student with the game, leaving him free to handle the geoespaço. Thus, their movements are not pre recorded and will be possible if libraries for developing three-dimensional graphics on mobile devices could be used.

The GeoEspaçoMob challenges were were classified into eight levels. The educators proposed to focus the development on the 3D visual perception because of the target public of the game. Although it also allows to explore other features of the spatial objects as their properties and measures calculations. Into each level, there is a question that will lead the student to think about some 3D concept analyzing the geoespaço board. Generally, the game will ask the player to identify or to make a calculation of any property of a spatial object exhibited at the geoespaço board.

In the general, eight levels were designed. Each level has a specific proposal for dealing with the content and provides a gradual difficulty increase of three-dimensional concepts and in the construction of its visualization. Then, the student is able to rationalise developing its three-dimensional visualization. The definition of each level of the game is:

- Level 1 - the main focus at this level would dealing with 3D viewing, primarily through the recognition of shapes;
- Level 2 - levels 2 and 3 are proposed to deal with the basis of the solid. Level 2 covers the perimeter of the base;
- Level 3 – deals with the issue of bases area of solid;
- Level 4 - conceptualizations of basic elements such as edges, faces, vertices, among others;
- Level 5 – deals with the viewing of solid. This phase aims to develop the perception of three-dimensional space polygons through the association of different concepts and properties;
- Level 6 – Explores the concepts of lateral area;
- Level 7 - Explore the concepts of total area;
- Level 8 - Explores a simple calculation of volume.

Because of the characteristics of geoespaço and complexity of building some solids, some decisions to the initial version of GeoEspaçoMob were taken:

- The solids that will be represented in geoespaço board are limited to prisms and pyramids;
- The bases of the solid are triangular, quadrilaterals, pentagonal, hexagonal or octagonal. However, for the challenges that involves calculation of area, perimeter

or volume, will only be used quadrilaterals base prisms, limited to rectangles and squares;

- The spatial objects will be straights, both the pyramids and prisms, that significantly reduces the number of pyramids that can appear in geoespaço.

Modeling Aspects

The previous definition of the plot and the challenges of the game is really important at the modeling phase. It must be avoided the definition of many classes to the system, because of the limitation of memory and processor of the mobile phones. The preference in the major of the cases is to avoid elegant and robust implementation, in order to eliminate redundancies, and dispensable entities to build a more efficient system. Figure 2 shows the class diagram of GeoEspaçoMob. The game has eight classes: GeoEspaco, 3DScene, Environment, Camera, Board, Taskmanager, Solid and Quadrilateral.

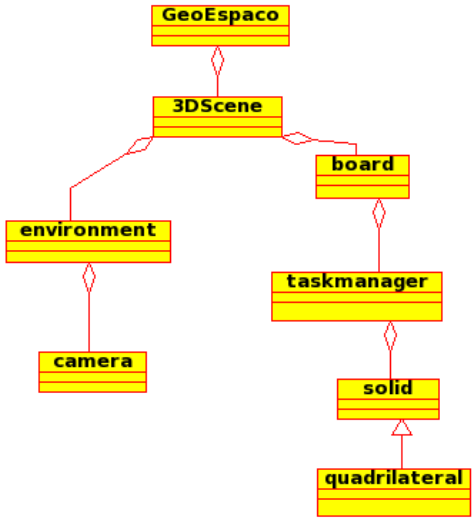

FIGURE. 2
GEOESPAÇOMOB CLASSES DIAGRAM.

The GeoEspaco class represents the game. It has as attributes the class of the graphical scene (3DScene) and some screens that are used to present the game and give information to the player. The 3DScene class imports the OpenGL ES API (a graphic API for mobile phones) to render the scenes defined by the classes Environment and Board. The Environment class defines the library corridor rooms and indicates all the information about these rooms. The Camera class defines the position of the camera and how can be the interactions between the environment and the user. The Board class defines the geoespaço board and receives from the TaskManager class the object that must be drawn - the challenge. This class also allows interactions between the user and the scene. The TaskManager class manages the challenges during the game. It has as attribute an array of solids that are the spatial objects which would be sent to the board. The Solid class stores the information of the geometry objects. The Quadrilateral class inherits from the Solid class and store some additional information that refers only for spatial objects whose bases are parallelograms.

RESULTS

In first messages of GeoEspaçoMob, the story of the game will be presented to the player in order to make him understand his goal at the game. Then the game starts to react according to the control of the player. The Figure 3 shows the first results of the cycle of screens of the game:

(1) The library corridor room is displayed and the player must look for a cube, that represents the geoespaço. To open the door to the next room he must take the cube and solve a problem. The first interactive screen of the game is in this step of the cycle;

(2) This step represents the player finding the geoespaço at the environment. After touch the cube the game leaves the library environment, and presents the problem to the player;

(3) At this step the geoespaço is shown to the player that try to answer correctly the question made for him analyzing the object in the board using the interactive manipulation;

(4) The game return to display the library corridor room. If the player have answered correctly the question, the door is opened. But if not, the door remains closed, the player return to the room and will look for a new geoespaço. At this time it will be given to him a tip.

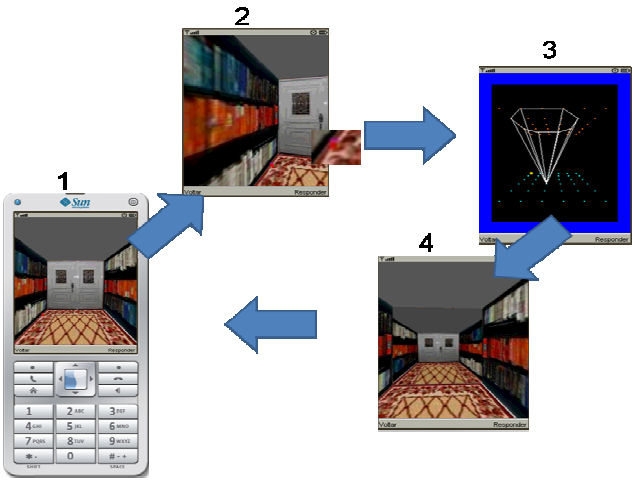

FIGURE. 3
FLOW OF THE GAME.

The GeoEspaçoMob has potential to supplant various limitations that were find in the implementation of

interactive 3D environments for mobile phones. The application is dedicated for use in the GPUs for mobile phones available in the last years, which will improve the quality and the perform of 3D graphics. Those graphic cards arise new possibilities to the developer and new features can be added in games for mobile phones.

CONCLUSION

The use of the 3D graphics can give some benefits for an application. It can improve it into a more intuitive, a more realistic and then a more attractive program. Besides, mobile 3D games can adequately be used as a facilitator of learning. Adding to the advantages of the educational games, the mobility of the mobile phones and the immersion of 3D environments.

GeoEspaçoMob, as an educational game, has a specific goal: to be a fun application that promotes the learning process. These aim must be respected along all the process of development. The results of this version of the GeoEspaçoMob have demonstrated that the use of three-dimensional graphics in mobile phones may originate satisfactory applications. As the GeoEspaçoMob is a game that deals with the spatial geometry, it was necessary to use the 3D graphics: it was not only for quality, or a question of using a novelty, it was necessary for the context of the application.

Teachers that participates of the development of GeoEspaçoMob emphasized the importance of this kind of game to the educational process. The game is still under development and will be validate with students when concluded.

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