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Educational Software for the Teaching of Astronomy using Immersive Virtual Reality

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Abstract

Objective: To describe a support tool for teaching astronomy based on immersive virtual reality, which contains an educational proposal based on interactive activities. **Methods:** The application allows the user to demonstrate, know and learn through several immersive virtual activities which enable and encourage the exploration and dissemination of topics related to astronomy. Concepts related to the objects of the Solar System, the types of Orbits and the phenomenon of Stellar Parallax are presented. **Findings:** The application serves as teaching material, allowing strengthening astronomical, physical and mathematical concepts in the user's learning process, additionally, the application allows teachers to be encouraged to incorporate new technologies in the classroom. **Application:** The application can be used in any context, either from a classroom, from home or for expository purposes about the topics contained in the virtual experience.

Keywords: Astronomy, Google Cardboard, Orbit's Types, Parallax phenomenon, Solar System, Virtual Reality

1. Introduction

Virtual reality is called to be one of the consumer technologies that will accompany the public in the coming years, many high-level companies are gradually increasing investment resources and research in technologies related to this field[1–4]. The developments of virtual reality generated today are characterized by covering multiple disciplines, by the search for a complete immersion, by the enrichment of experiences using a variety of complementary devices and by the wide spectrum of applications in industry, in entertainment and in education.

The virtual reality has made contributions in various contexts[4], particularly in astronomy, has helped and encouraged the improvement of research processes and learning processes. The use of these technologies has allowed creating applications[5–10] with virtual reality and augmented reality or issues with outer space[11–13] generating new alternatives to show several topics, among them the Solar System, the phases of the Moon, among others. Multiple applications developed today have been made using the Internet[8–10], using interactive videos, planetariums in scenarios such as fulldome[9] or museum[14], with the use of programs such as VRML (Virtual Reality Modelling Language)[14]. These materials have been used to motivate users in order to improve performance in the learning process.

This document presents a proposal of didactic material to support the teaching of basic astronomy using software based on immersive virtual reality. The application addresses issues about the Solar System, the types of orbit and the phenomenon of Stellar Parallax. The intention is to encourage the user to explore and investigate the study of astronomy, for which interactive activities were carried out relating each of the topics and allowing the user to be immersed in an interplanetary trip.

Each of the proposed activities contains work guides making use of explanatory audios, which narrate and describe concepts as changes are generated during each activity. Some of the concepts that the user evidences in each of the activities are: the gravitational attraction force between the sun and the planets, the gravitational attraction between the Earth and the artificial satellites in orbit, the first and third Kepler's law, the difference that each orbit has according to the distance in which each celestial

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body is and its period of rotation, the parallax phenomenon, among others.

2. Methodology

The product developed is an immersive virtual reality application for mobile platforms. It was generated with the intention of being used as a tool to support the teaching of concepts related to basic astronomy, with or without the direct accompaniment of a teacher.

2.1 Proposed Activities

The activities developed are divided into three parts:

- The first part of the application is composed of three activities on the Solar System theme, in the first activity the movements of the bodies of the Solar System are evidenced: The Sun, the planets and comets; This scenario shows the movements of rotation and translation of each planet around the Sun including some comets, the intention is for the user to relate and visually strengthen the concepts of the conformation of the Solar System, the distances, sizes and spatial location of each element in orbit. In the second activity an interplanetary trip is made, during the displacement the planets are visited while narrating details related to what is observed, in particular the calculation of the relative age of the user in years, months and days referring to each body visited. The objective is to detail the characteristics that each planet has regarding its rotation, translation, size, the number of moons that it orbits in each one and to show the relative that it is a day or a year using the age of the user as reference of comparison. The third activity corresponds to the visit to a planetary gallery; in this case the bodies are presented in a way that allows the contrast of their characteristics.
- The second part is based on the theme of orbits, using as reference the artificial satellites of the earth. An activity was generated in which the differences between each type of orbit of the satellites are described, related to their relative location and the functionalities that each one has in telecommunications. The dive allows the user to travel the orbit generated by each satellite, observing the planet Earth from different references in movement, meanwhile they are narrating how the Earth's gravity influences the stability of the satellite and what are the conditions and properties of each position, going into details about the geostationary orbits.
- In the third theme the phenomenon of the Star Parallax is exemplified. An activity was generated in which the user can experience how this comparison technique is used. For this, three different star groups were implemented, which represent 3 different cases of the same phenomenon. The immersion generated allows the experience to be novel with respect to the exemplification of this particular topic. The purpose of the activity is to show the user how this phenomenon is analyzed and what the apparent movement that the stars have in a period of 6 months. The teaching process is also achieved through analogies of everyday life relating parallax terms and detailing this phenomenon in other contexts, such as photography, applications with the Pythagorean Theorem, among others.

2.2 Interaction Mechanics

The control of the application is made using a cursor which moves according to the movements of the head, the cursor allows click by focusing for a few seconds the interactive elements within the scenario. This interaction mechanics has the advantage of not requiring the use of an external button, for example, the keyboard or the mouse. Each interactive activity was created in order to be comfortable for the user, so that he does not move his head backwards, just keep the front view generating 250°.

When you start the application, you will find the main menu, this menu has the option to "Start" and the user can choose this button in a time of 2 seconds. Then, to travel in each of the scenes, the user has the option of choosing which activity to explore.

3. Results and Discussion

The application addresses three themes based on the concepts of astronomy so that the user, besides observing and evidencing each event, can interact in the virtual environment and listen to its explanation. Next, the final stations selected to be part of the application will be described.

3.1 Movements in the Solar System

Upon entering the scenario called "Solar System" the user can learn and verify knowledge related to the application of Kepler's laws. In particular the first law related to the movement of each planet around the Sun, in addition, the demonstration of the third law related to the time it takes the planet to perform its trajectory of translation with the average distance of the Sun, the user checks this law observing the location of each planet with its respective characteristics, the periods of rotation and translation.

Another theme is the visualization of the Moon's orbit demarcating its trajectory of rotation around the Earth, the importance of observing the Moon's orbit is that by means of its rotation it generates the phases of the moon, besides the verification that natural satellites comply with Kepler's laws and the user evidences the translation generated by the Moon to the passage of the translation of the Earth, shown in Figure 1. The user can activate this option by means of the button "See orbit of the Moon" and if you want to visualize the solar system again, choose the "View Solar System" button.

The user can change the frame of reference from which he will observe the phenomenon, since he can do it taking as reference any object within the scene, this allows, for example, to show the movement that the Sun has and in general the whole system with respect to the galaxy Figure 2. The idea is that the user will be able to compare both the dynamic and the static movements of the

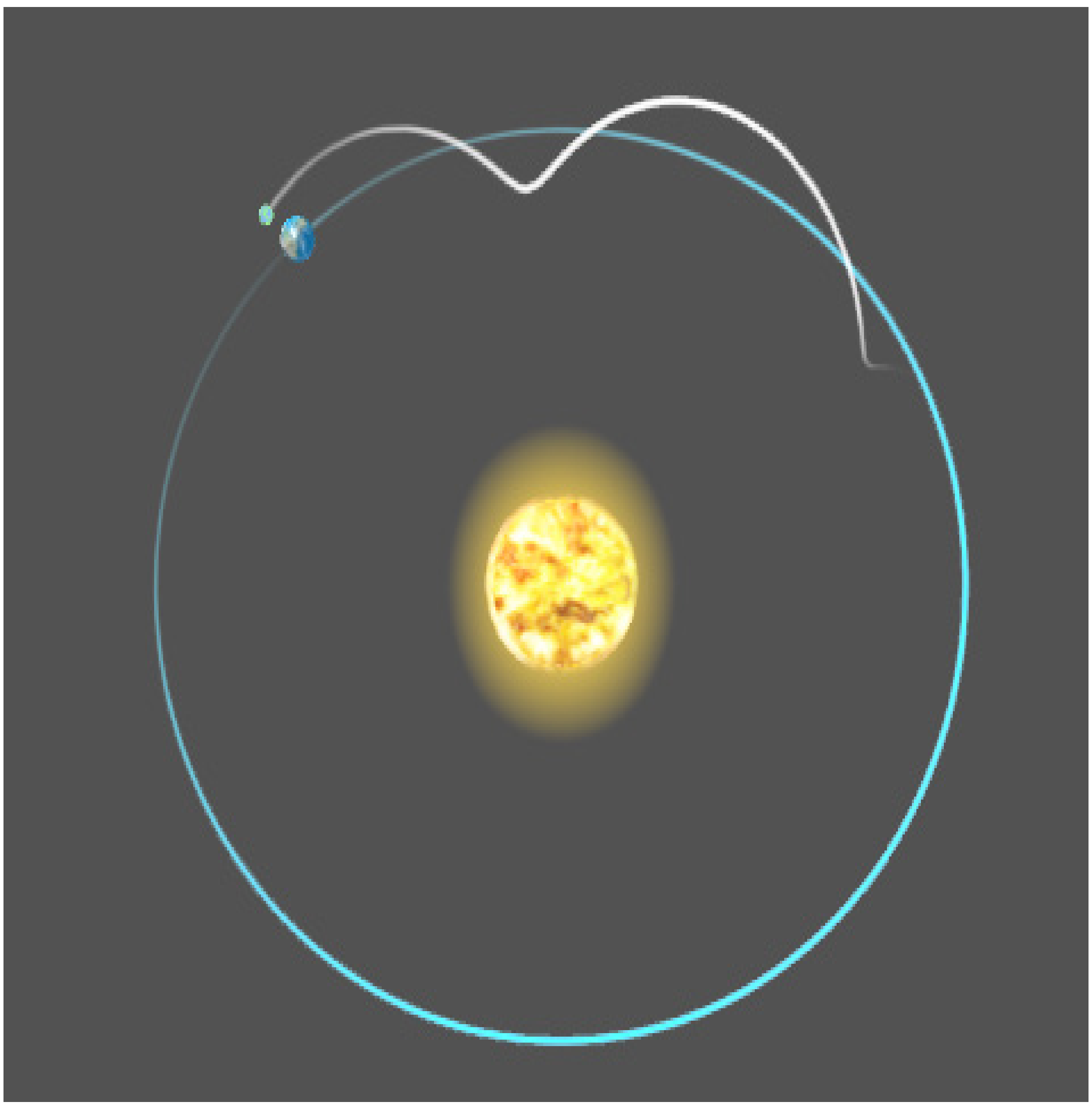

Figure 1. Orbit of the Moon.

Solar System, analysing and concluding that the Universe is in constant movement and growth not only the planets, natural satellites, comets and the Sun, but the variety of galaxies that make it up.

The activity consists in entering the age of the user, focusing with the pointer the numbers that are located in the bottom part, then the information of the age in years and days elapsed in the Earth will be shown, this is due to the period of rotation which is 24 hours and its translation of 365 days. Later this information can be contrasted with the rest of the planets of the solar system, making it possible for each user to observe what their age would be in terms of years and days of each planet. The user has the freedom to choose which planet he wants to visit, there he

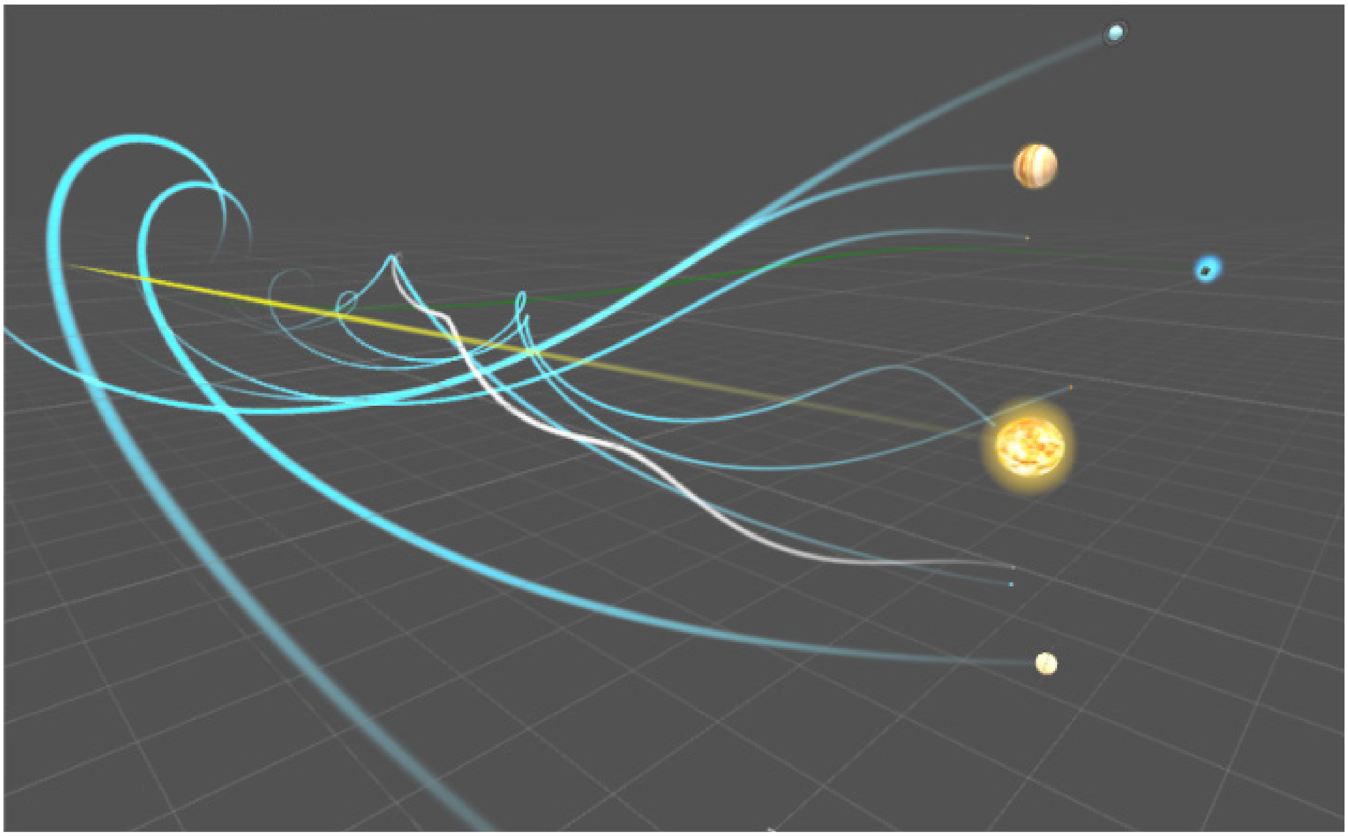

Figure 2. Movement of the Solar System together with the translation of each planet.

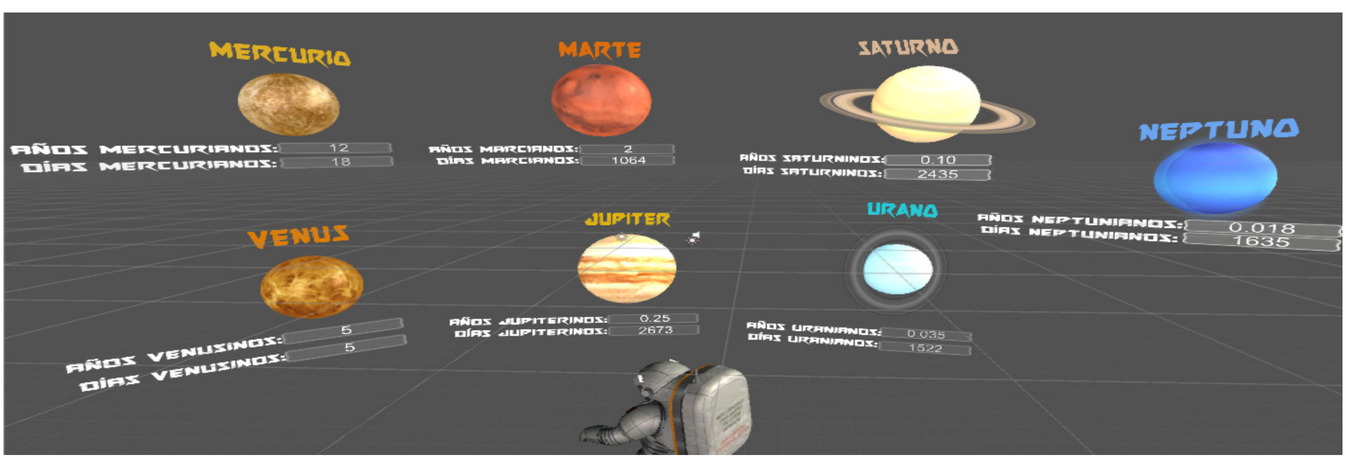

Figure 3. Planetary gallery for the calculation of ages.

will be able to visualize the information of the age in years and days that he would have in that planet. The importance is that as you move away from the sun the age will be less and less, in addition to the purpose of comparing the data, at the end of the activity conclusions are generated that allow contrasting the information presented (Figure 3).

3.2 Types of Orbits

This interactive activity aims to expose some types of orbit using as reference the planet Earth and satellites used for telecommunications. It is expected that the user will learn to differentiate the types of orbit that is generated around the Earth, identifying the position of the artificial satellite, its stability from the Earth's gravity, the conservation of energies and its functionalities that it contributes to communications. . Initially, when entering the activity, the user will visualize the Earth with three orbits in motion: The Geostationary Orbit (GEO), the Low Orbit (LEO) and the elliptical or High Orbit (HEO) with its respective artificial satellite. The activity has an explanation that makes evident the parameters and the associated concepts, among them, the distance in which each satellite is located, its speed in a round around the Earth and the functionality that they have in communications and in the taking pictures.

3.3 Stellar Parallax

The fourth scene explains how the distances between the stars are measured. This phenomenon applies to relatively

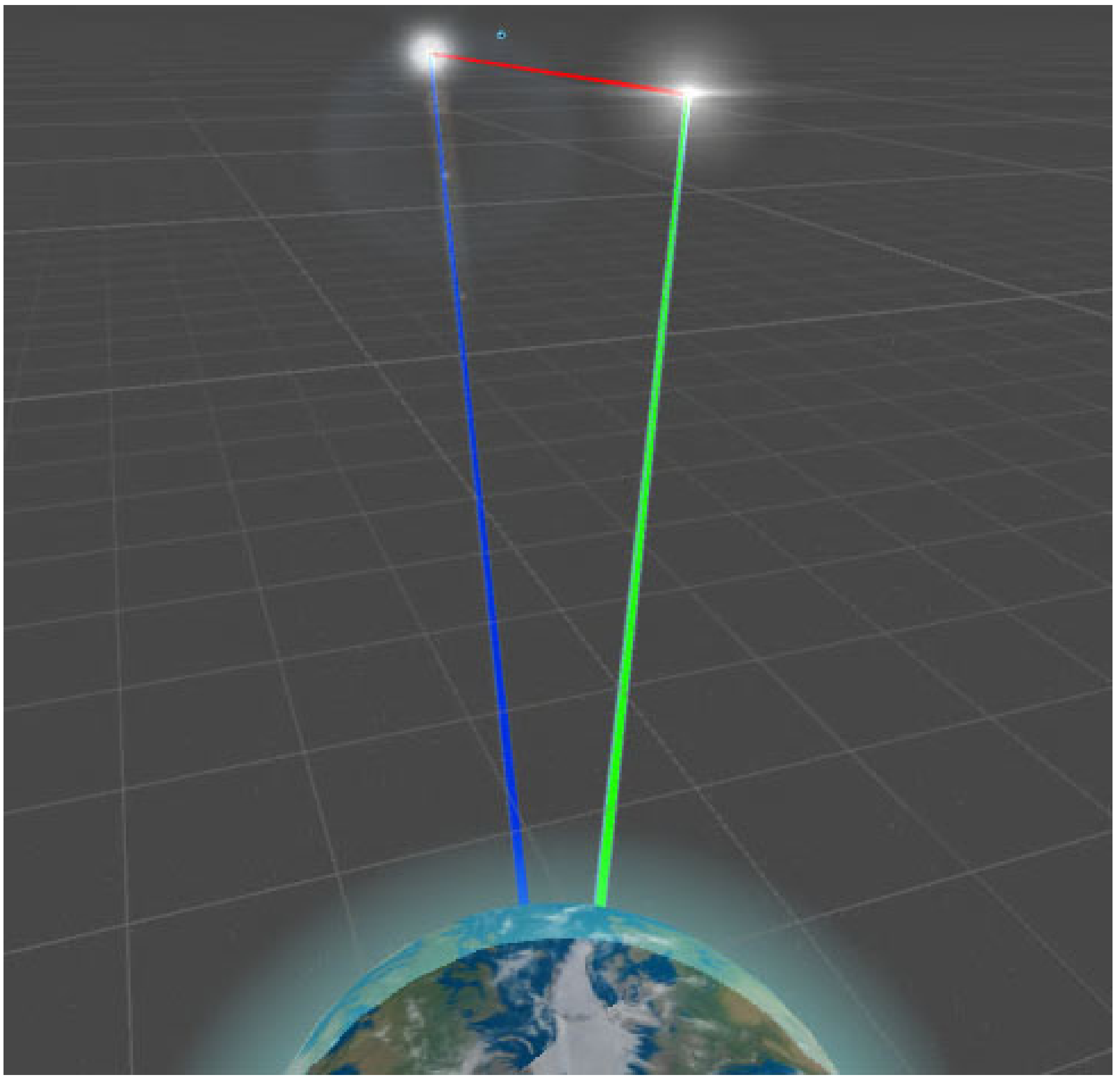

Figure 4. Projection from Planet Earth to the two stars.

close stars, because farther stars have very small parallax angles that are difficult to measure. The user can demonstrate this phenomenon by interacting with a group of stars. Initially, the user will be located at a point near the line of the Equator and the distance between the Earth and the chosen stars will be drawn with lines forming a type of right triangle (Figures 4 and 5). During the translation of the planet Earth, the change of position that apparently has the stars of the closest one to the most distant one after six months is visualized (Figure 6). In this period the maximum distance that there is of a star is calculated, the other with the point of reference that is the Earth. The user can perform this procedure with several examples that we consider representative on the subject, which will allow him to argue and show the changes that occur when being in a different perspective.

The described application consists of several interactive activities that are proposed in order to strengthen specific concepts of astronomy. The user is expected to investigate, deduce, analyse, reflect and interpret what the characteristics and structures of celestial bodies, planets, comets, stars and others are really like and take it as an innovative technological resource used to explain differently and lucid concrete astronomy using an interplanetary trip as a base. The application allows teachers to be encouraged to incorporate new technologies in the classroom, allowing them to teach with a scientific conception of the entire universe, seeking that the process is not learning by transmission but an interactive learning. It is expected that schools incorporate applications such as the proposal, so that their students are interested in researching, discovering, understanding, developing the

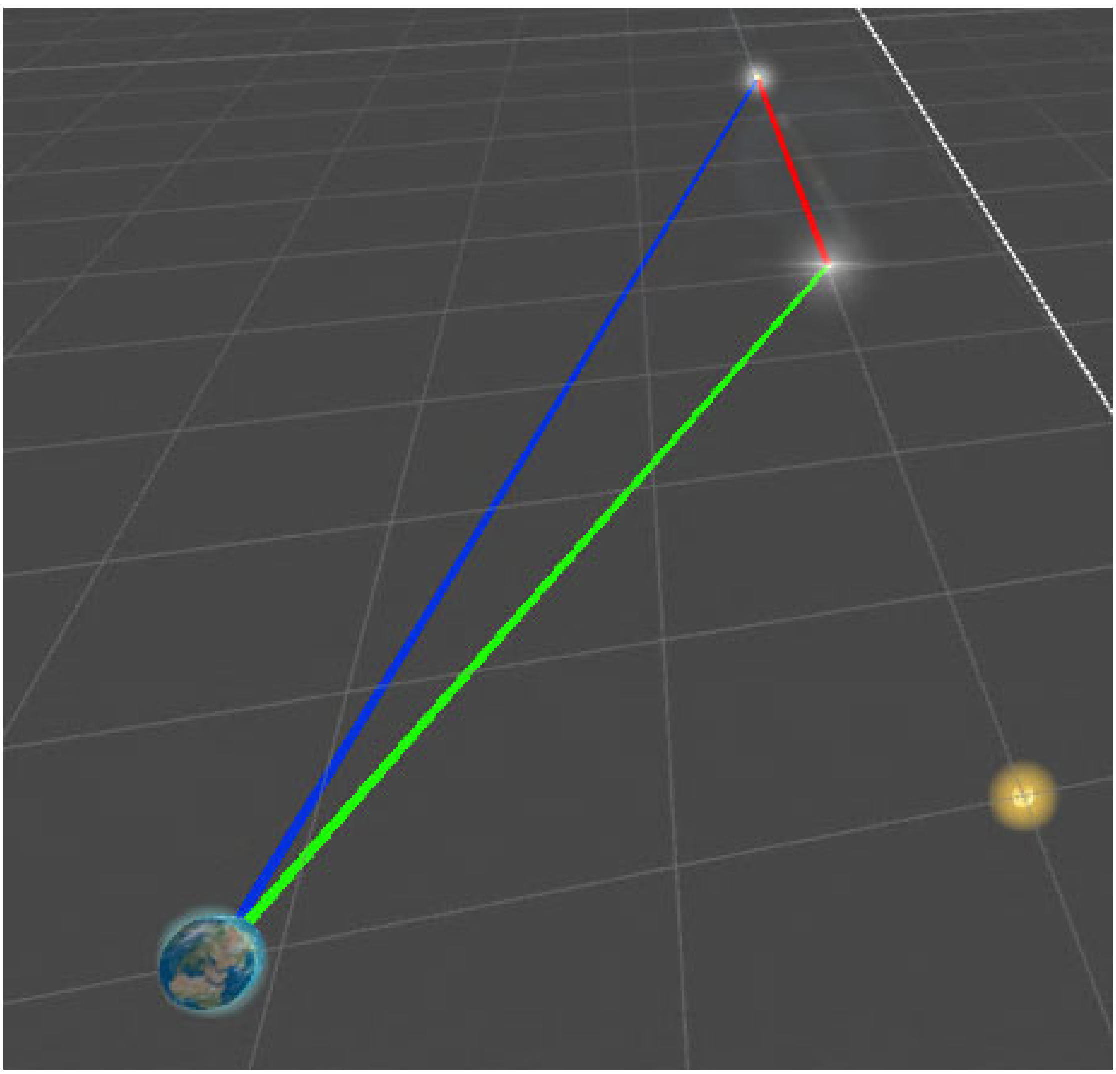

Figure 5. Projection from Planet Earth to the two stars forming a right triangle.

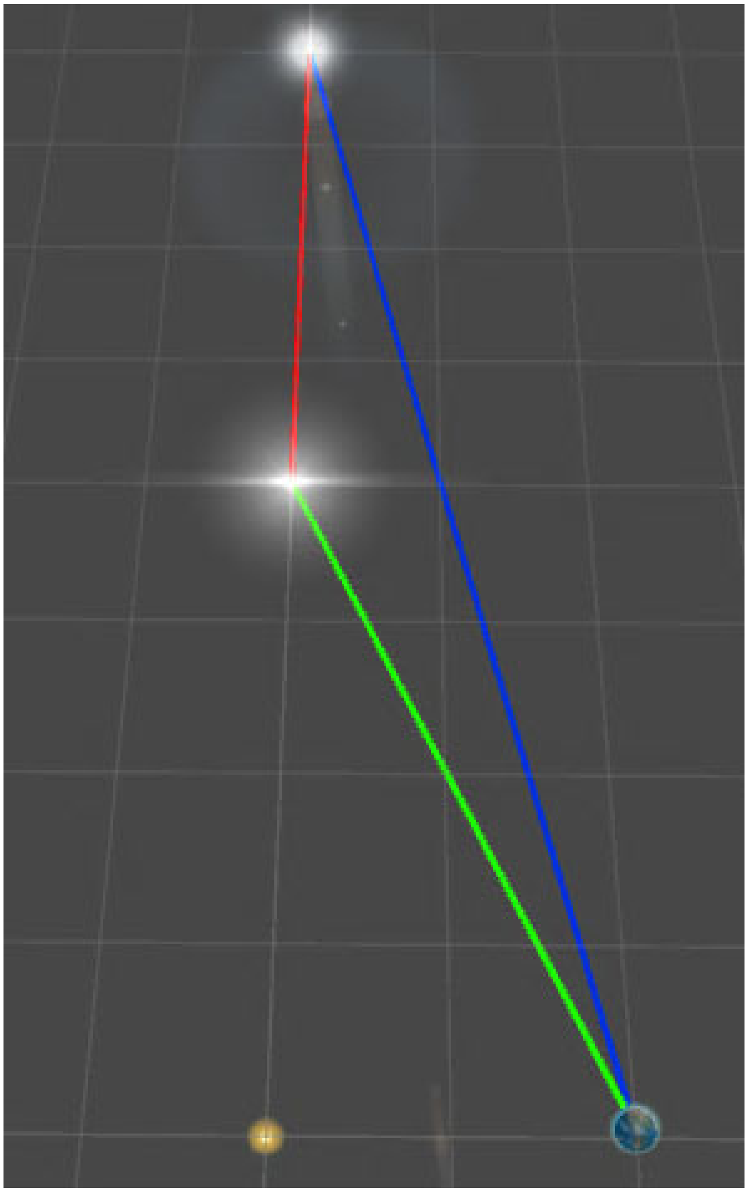

Figure 6. Projection of the stars after 6 months of translation of the Earth.

observation capacity, allowing the formulation of questions and hypothesis statements and build their own knowledge in a virtual experience.

The application can be used in any context, either from a classroom, from home or for expository purposes about the topics contained in the virtual experience, the important thing is that anyone can interact and learn new concepts in a didactic way, experiencing the sensation of being immersed in virtual scenarios, creating a wider and richer vision of the world that surrounds us and of what could happen in the future not only with the planet Earth but in each one of the bodies that make up the universe.

4. Conclusions

The didactic experience was designed with the purpose of contributing to the learning processes in the education of astronomical subjects using concepts such as the conformation of the Solar System, its movements and planets, the types of orbit and the phenomenon of stellar parallax, using reality Virtual as a strategy. The application serves as teaching material, allowing strengthening astronomical, physical and mathematical concepts in the user's learning process, through the illustrations and animations of astronomy events for the incorporation of technological tools in any environment, generating motivation to research and experimentation of new advances.

In each of the activities of the application the user will have a closer approximation to the planets according to their shape, spatial location, approximate size and in their movements or of some satellites orbiting around the Earth, in order to create the immersion in a virtual world.

5. References

1. Heras L, Villarreal JL. La realidad virtual en los nuevos paradigmas de la ciencia de datos. Revista Digital Universitaria. 2011; 12(9):1–6.
2. Diaz A. Inmersion mental y realidad virtual. Revista Uciencia: Divulgacion científica de la Universidad de Malaga. 2011; 6:30–3.
3. Arevalo C, Trejos OI, Veloza, J, Olarte JC. Realidad virtual, destinada al desarrollo de aplicaciones para las diferentes áreas del conocimiento. Revista Scientia et Technica A-o XII. 2006; 1(30):1–5.
4. Zapatero D. La realidad virtual como recurso y herramienta útil para la docencia y la investigacion. Revista Iberoamericana de Tecnología en Educacion y Educacion en Tecnología (TE and ET). 2011; 6:17–23.
5. Sarmiento J, Angulo E. Dise-o e Implementacion de una herramienta didactica para la ense-anza de los principios de astronomia a ni-os mediante realidad Aumentada, en la fundacion Colegio Cristiano de Cartagena. Universidad Nacional abierta y a distancia UNAD, Cartagena de Indias; 2015. p. 1–79.
6. Gonzalo J, Horacio H. Realidad virtual aplicada en el contexto de la educacion no formal. Conferencia llevada a cabo en el VIII Congreso de educacion a Distancia Cread Mercosur; Cordoba, Argentina. 2004. p. 1–9. PMCid: PMC1809048.
7. Gonzalez LY. Dise-ar e implementar una unidad didactica interactiva para la ense-anza- aprendizaje con herramientas TIC del tema ubicación geografica y espacial en astronomía para estudiantes del grado undécimo. Medellín, Colombia: Universidad Nacional de Colombia; 2012. p. 108. PMid: 22055073.
8. Serrano N. Las oportunidades pedagogicas de los espacios inmersivos: Los beneficios del Fulldome como herramienta de aprendizaje. Espa-a; 2015. p. 1–16. PMCid: PMC4852880.
9. Faundez CA, Bravo AA, Melo AD, Astudillo H. Laboratorio Virtual para la unidad Tierra y Universo como parte de la formacion Universitaria de docentes de ciencias. Formacion universitaria. 2014; 7(3):33–40. https://doi.org/10.4067/S0718-50062014000300005
10. Huan H. Interactive visualization of space science data in virtual 3D scene. Second International Symposium on Intelligent Information Technology Application; 2008. p. 371–5.
11. L Ni. Application of haptic, visual and audio integration in astronomy education. Haptic Audiovisual Environments and their Applications; New York: McGraw-Hill. 2006. p.152–6.
12. Gantiva D, Gantiva E, Rivera D. ENIGMATRONIC: An Educational Videogame, Inted2016 Proceedings; 2016. p. 2686–94.
13. Otero A, Flores J. Realidad Virtual: Un medio de comunicacion de contenidos. Aplicacion como herramienta educativa y factores de dise-o e implantacion en museos y espacios publicos. Revista Icono 14. 2011; 2:185–211.
14. Quintana P, Bouchard S, Serrano B, Cardenas G. Efectos secundarios negativos de la inmersion con realidad virtual en poblaciones clínicas que padecen ansiedad. Revista de Psicopatologia y Psicología Clínica. 2014; 19(3):197–207. https://doi.org/10.5944/rppc.vol.19.num.3.2014.13901