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Augmented reality and stellarium: astronomy for children of five years

Realidad Aumentada y stellarium: astronomía para niños y niñas de cinco años

Sandra Pérez-Lisboa is a professor at Universidad de Playa Ancha (Chile) (sandra.perez@upla.cl) (https://orcid.org/0000-0002-0389-7242)

Carmen Gloria Ríos-Binimelis is a professor at Universidad de Valparaíso (Chile) (carmengloria.rios@uv.cl) (https://orcid.org/0000-0001-5800-6788)

Javier Castillo Allaria is a professor at Universidad de Playa Ancha (Chile) (javier.castillo@upla.cl) (https://orcid.org/0000-0001-8050-8231)

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Abstract

Educators are called to favor digital literacy, introducing the different technological tools for educational purposes since they are part of the daily use of children. Augmented reality and the Stellarium program are powerful tools for teaching astronomy, since they allow observing the stars, constellations and solar system, facilitating the explanation of celestial phenomena to the educator. The objective of this study was to analyze the educational intervention with augmented reality and the Stellarium program, in the development of astronomical language, specifically the semantic and morphosyntactic aspect of the solar system, stars and constellations, for five-year-old boys and girls. The educational intervention was carried out in the Didactic Classroom of the University of Playa Ancha and applied to the children of the Major Transition Level, of three municipal establishments: Liceo San Felipe and the Almendral and José Bernardo Suárez Schools. Through a quasi-experimental study (pre and post test), the progress of the fifty-three boys and girls who participated in the study through two tests was analyzed. The results obtained evidenced the progress in scientific language by recognizing elements of the universe —semantic aspect— expressing ideas and explanations about astronomical events —morphosyntactic aspect— that children knew in the educational intervention.

Keywords: Language, astronomy, augmented reality, Stellarium program.

Resumen

Los educadores están llamados a favorecer la alfabetización digital, introduciendo las distintas herramientas tecnológicas con fines educativos ya que son parte del uso cotidiano de los niños y niñas. La Realidad Aumentada y el programa Stellarium, son poderosas herramientas para la enseñanza de la Astronomía, ya que permiten observar las estrellas, constelaciones y sistema solar, facilitando la explicación de los fenómenos celestes al educador/a. El presente estudio tuvo como objetivo analizar la intervención educativa con Realidad Aumentada y el programa Stellarium, en el desarrollo de lenguaje astronómico, específicamente el aspecto semántico y morfosintáctico sobre el sistema solar, estrellas y constelaciones, para niños y niñas de cinco años de edad. La intervención educativa fue llevada a cabo en el Aula Didáctica de la Universidad de Playa Ancha y aplicada a los niños y niñas del Nivel de Transición Mayor, de tres establecimientos municipales: Liceo San Felipe y las Escuelas Almendral y José Bernardo Suárez. Por medio de un estudio cuasi experimental (pre y post test), se analizó el avance que tuvieron los cincuenta y tres niños y niñas que participaron del estudio a través de dos test. Los resultados obtenidos evidenciaron el avance en el lenguaje científico al reconocer elementos del universo —aspecto semántico— expresar ideas y explicaciones sobre eventos astronómicos —aspecto morfosintáctico— que los niños y niñas conoció en la intervención educativa.

Descriptores: Lenguaje, astronomía, Realidad Aumentada, programa Stellarium.

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1. Introduction

In the current educational scenario, communication and information technologies, such as the whiteboard, the Internet and its learning resources (digital and virtual as educational software), can be good resources for the teaching of Astronomy, as they allow children to observe the stars and constellations, just as they would look them at night. According to Vargas and Maya "the use of simplified models for teaching is an important resource for the teaching of science, because resorting to everyday-visual experiences favors the formation of mental images" (2007, p. 2). Interactive educational resources are part of these technological means that can promote better learning, because the use of multimedia materials (simulators and Augmented Reality) provide teaching options that facilitate an effective process and better quality education. In this regard, Bartolomé-Pina, García-Ruiz, and Aguaded point out that "trends continue to grow and new devices, increasingly accessible and ubiquitous, come with new technological trends and teaching strategies such as augmented reality (2018, p. 34). It is important to note that according to De Lima and Moreira (2019) the incorporation of ICTs into teaching contributes to the empowerment of pedagogical actions by educators.

Astronomy is one of the oldest sciences, but given to the technological growth it is also a modern science. Astronomy arouses curiosity in children, reason for which the Ministry of Education contemplates in the Curriculum of Initial Education, in the Exploration of the Natural Environment, the teaching of astronomy. In this way, "it is hoped to promote in girls and boys the skills, attitudes and knowledge that allow them to understand, appreciate and care for their natural environment, enhancing their curiosity and capacity for wonder" (Subsecretaría de Educación Parvularia, 2017, p. 83). From a young age, children have concrete astronomical experiences of observing the sky especially the moon, the sun and the stars, causing in them curiosity, questions and, above all, a lot of diverse questions and ideas, which it is essential to rescue when developing the topic in the classroom. In this regard Martin, Sexton, Franklin and Gerlovich (2005) point out that people who have received an education in astronomy can better understand the environment in which they live and position themselves individually within the universe. Children create their perceptions of different aspects of the macrocosm, which contrast with new scientific concepts, in an attempt to understand the phenomena of the natural world (Vosniadou & Brewer, 1992). This process requires early intervention that provides environments and tools for the development of ideas and new concepts. According to Galperin (2015), to generate changes in the way celestial phenomena are related to "supernatural" explanations, it is necessary for the education system to start incorporating them into its curriculum at an early age.

This study aimed to analyze educational intervention with augmented reality and the Stellarium program, in the development of astronomical language, specifically the semantic and morphosintactic aspect about the solar system, stars and constellations for five-year-old students.

1.1. Augmented Reality

The term "Augmented Reality" (AR) was first used in 1992, by Tom Caudell to designate experiences in which digital information (by means of text, image, audio, video, 3D objects or others) is added to a real-time physical world view. To perform this overlapping of virtual and real information, it is necessary to use technological devices such as: computers with webcams, or laptops, tablets or smartphones. According to Gómez (2013), AR is that environment in which takes place the integration of the virtual and the real. On the other hand, Cabero and Barroso (2016), points out that the use of AR in educational contexts allows to improve the training actions, therefore, students increase the levels of learning by creating these technological scenarios.

The application of AR in education is mostly due to the use of portable devices, smartphones and tablets and for teaching purposes. It is what it is known as mobile-learning, or m-learning, which Quinn (2000), points to as a type of e-learning through mobile devices. For their part, Basogain, Olabe, Espinosa, Rouèche and Olabe (2007) state that "augmented reality does not replace the real world with a virtual one, but on the contrary, maintains the real world that the user sees by complementing it with virtual information superimposed on the real" (2007, p. 1).

In the educational context, the literature notes that the use of RA positively influences the motivation of the students. One of them is that of Cubillo, Gutiérrez, Gil, and Colmenar, mentioning that AR "facilitates, motivates and makes the explanation and assimilation of the contents more pleasant for both teachers and students, while stimulating and motivating learning" (2014, p. 248). On the other hand, Reinoso says that "... AR strengthens learning and increases motivation to learn" (2012, p. 371). Also, Fonseca, Redondo and Valls (2016), say that the experience of using real-world images is satisfying and motivating because it allows a greater understanding of the space. Also according to Prendes (2015), this tool is used to provide internships to students with some medical applications. However, it is essential that teachers are trained to use the application, so they can interact with students throughout the learning process (Oluwadare, 2015).

1.2. Use of simulators in Astronomy

According to *Real Academia Española* (RAE) the term simulation comes from the Latin *simulatio,* -**ō**nis, and it is the "action and effect of simulating". Therefore, it consists in placing the student in a context that imitates some aspect of reality in this environment, stablishing situations that the student would have to face in a real context. Salas (1995), notes that students concentrate better on a given object by using simulation in the teaching process.

The Stellarium program has open source and is a software that allows the computer to use it as a planetarium since the sky is exhibited in 3D, as can be seen with the naked eye with telescope or binoculars. It points to the positions of the stars, the sun, the planets and the moon, and depending on the location and time, it shows how an observer sees the sky. It also simulates astronomical phenomena such as lunar or solar eclipses, meteor showers and it draws constellations. As an educational tool, it allows to teach the night sky, it helps the observation for amateur astronomers, or simply as a curiosity to encourage the study of planetary sciences.

The various programs that have been created through technology "... are important because of the diversity of possibilities they offer to create new communicative scenography for teaching" (Aguaded & Cabero, 2014, p.71). Therefore, the use of the Stellarium program is a simplified model of great importance for the teaching of science, since by requiring visual experiences as everyday it allows the formation of mental images, facilitating the notion approximation of astronomy (Vargas & Maya, 2007).

1.3. Astronomy in childhood

Astronomy comes from the lat. "astronomĭa, and this from the gr. ἀστρονομία"; as a science, it studies the universe beyond the earth's atmosphere, including the sun, moon, the planets and the stars (Brewer, 2001; Eliason & Jenkins, 2011). These topics are of great interest to the little ones, since day and night, the sun, the moon and the stars are part of the experiences they live daily because they are in their environment. For Educarchile "astronomy in school offers valuable opportunities for strengthening the personality and development of children's cognitive skills, who acquire a deeper view of their place in the world and receive tools" (online). For this reason,

Ampartzaki and Kalogiannakis (2016) work on a project that has a multidisciplinary approach and it is based on concepts that they consider essential to the teaching of astronomy, which are spatial learning and spatial thought.

Kallery (2010), notes that there are few studies aimed at astronomy and these are relatively limited compared to the number of studies on other disciplines. At the national level, the report 'Reaching the Stars: Findings of the Chilean-American Summits on Education and Dissemination of Astronomy' only points out the teaching of astronomy at the level of Elementary and Higher education, leaving aside various proposals that are being implemented.

According to Cabello (2011), astronomy originated from the natural curiosity that children have to understand natural phenomena and answer the questions with more rigorous explanations. Developing positive attitudes towards astronomy is a significant part of scientific literacy for contemporary societies (Uçar & Demircioğlu, 2011). In addition, according to Nussbaum (1989), it must be considered that children have concrete astronomical experiences, ideas and theories linked to them from an early age. Therefore, an educational intervention is proposed for five-year-old students in the learning of astronomy language on the solar system, stars and constellations, using augmented reality and the Stellarium program.

1.4. Educational intervention

Educational interventions were applied in the Didactic Classroom of the Children Education Career of the University of Playa Ancha, San Felipe Campus. In this Didactic Classroom, "activities that go beyond memoristic learning are carried out, which aim to train the understanding of the contents through technological tools of the S XXI" (Pérez- Lisboa & Caldeiro, 2016, p. 184). The tools used were the Stellarium and AR simulator which were used to implement the educational experiences.

The contents seen by the children teachers in the educational intervention were separated into three units, each divided into four 60-minute sessions. The contents viewed in each unit are detailed in the following table.

Table 1. Contents and sessions

Unit	Sessions
Solar System	The Sun
	Planets
	Comets
	The Moon
The Stars	What are the stars
	Star Evolution
	HR Diagram
	Star Groupings
Constellations	What are the constellations
	History and legends of the sky
	Constellations of the original people
	Locating the constellations

The Stellarium simulator was used in every 60-minute session by the teacher in the first and third units. This tool was chosen as it shows the night sky and its evolution over time. In the first unit, this tool allowed showing children the trajectories that planets have in the sky and the months in which they can be seen. Also, it points out the movements of the moon and its phases. In the third unit, the simulator was used to teach what the constellations are, their location and their shapes. This program was selected because of its excellent graphics, since not only are the lines that join the stars observed, but it also shows the images of the mythological beings and objects they represent, allowing at the same time the teacher to tell legends associated with them, in the different mythologies (classic and original people).

Augmented reality was used in units one and two since 3D images of planets, satellites and stars were available, so that students could appreciate their main characteristics using the different senses.

2. Methodology

The design of this research corresponds to a quasi-experimental study with pre-test/post-test (Hernández Sampieri, Fernández Collado & Baptista, 2014) because researchers only observe and analyze the teaching-learning process that is carried out by ICT.

The tests that were applied to the population under study were two. The first analyzed the level of the semantic aspect of the child, and the second analyzed the morphosintactic level of students of the astronomical language taught in the educational intervention. The tests were prepared by researchers and validated by expert judgement. The first test consists of eight sheets, each sheet has four astronomical objects, where the child must point to the object named by the examiner. The second test has fourteen questions, in the first three he/she must complete the sentences, in the next three the student must identify the wrong term, in the three successive ones, the student should indicate what happens to each celestial body, in the three that follow the student must create a sentence with the element mentioned and in the last two the student must say all the things he/she knows of the named celestial body. For both tests, the student is given a point if the answer is wrong and two points if the answer is correct.

The sample of the study corresponded to fifty-three children from the municipal establishments: Liceo San Felipe (sixteen), Escuela Almendral (eighteen) and Escuela José Bernardo Suárez (nineteen). The educational intervention was carried out in 12 sessions, which were developed in the Didactic Classroom of the University of Playa Ancha, San Felipe Campus. The working group was made up of the main investigator, a kindergarten educator, a scientific advisor and a computer engineer.

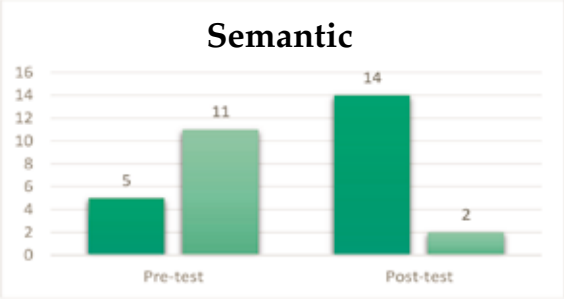
3. Results and discussion

This quasi-experimental research analyzes the results of an educational intervention using augmented reality and the Stellarium program for five-year-old students in the learning of astronomy. The fifty-three children who participated in the educational intervention were developing the semantic and morphosyntactic aspects of the solar system, stars and constellations.

The application of the test that evaluated the semantic aspect allowed to know the advancement in the vocabulary of the concepts of sun, moon, Earth, Mars, Saturn, constellation, star and comet. The pre- and post-test results will then be examined.

San Felipe School

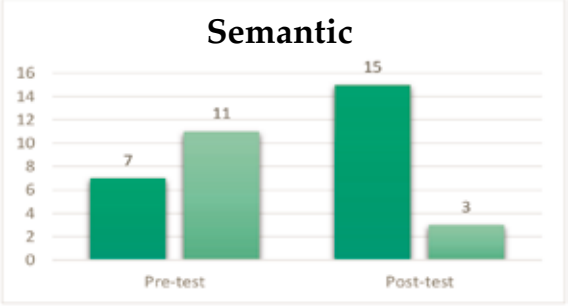
Figure 1. Results of the semantic assessment



The sixteen children who participated in the intervention of San Felipe school, Figure 1, were learning the concepts. In the pre-test, only five knew the terms, in the post-test fourteen children managed to identify the concepts taught.

Almendral school

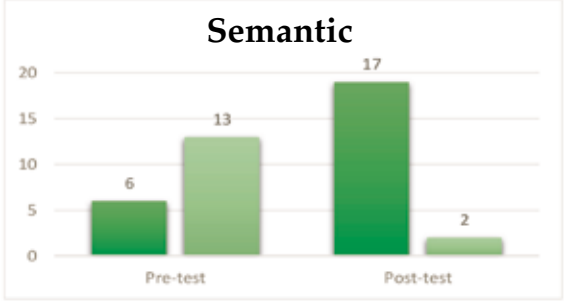
Figure 2. Results of the semantic assessment



From the eighteen children who participated, Figure 2, most of them were assimilating the concepts evaluated. In the pre-test there were only six identifying the terms, in the post-test seventeen children knew all the concepts explained in the educational intervention.

José Bernardo Suárez School

Figure 3. Results of the semantic assessment



From the nineteen children who participated in the intervention at José Bernardo Suárez school, Figure 3, most of them were learning the concepts. In the pre-test only six knew the terms, in the post-test seventeen students managed to identify the concepts taught.

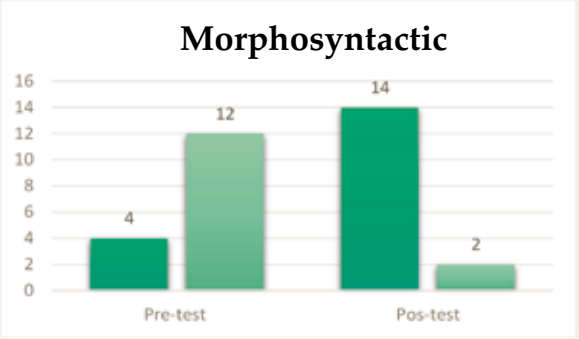
The analysis of the three institutions shows a significant advance in the learning of concepts, the semantic aspect "relates to the awareness and organization of linguistic content in memory and to the fluency to establish significant relationships that the person has" (Pérez-Lisboa, 2017, p. 6). In this regard, Kallery (2010) points out that astronomical concepts such as day and night change and the sphericity of the land that are considered difficult for young children can be understood if presented with teaching strategies that motivate them. According to Pérez, Castillo and Ríos (2017), "AR create close and meaningful learning experiences in children", allowing learning. On the other hand, Longhini and Menezes (2010), point out that the use of the Stellarium program is a tool that reveals a high educational potential, since it has more than 600,000 stars; illustrations of the constellations; planets of the solar system and its satellites, solar

and moon eclipses, among others. Additionally, Stellarium significantly reinforces the contents taught in class (Sá Muniz & da Silva, 2015).

Continuing the analysis, the morphosyntactic aspect was done to evaluate the completion of phrases, detect errors in phrases, establishments of causal relationships, construction of phrases and enumeration of elements belonging to certain verbal categories. The results of each institution are presented below.

San Felipe School

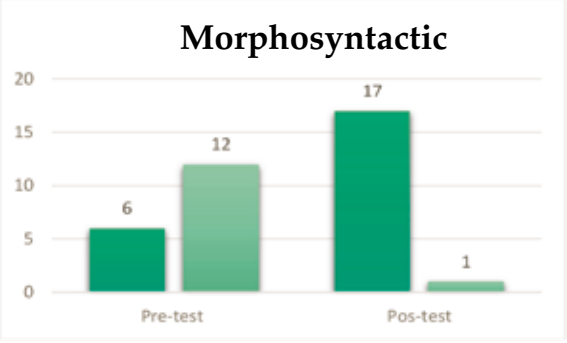
Figure 4. Results of the morphosyntactic assessment



In San Felipe school, Figure 4, is observed that children made significant progress in constructing sentences, using the astronomical language they were learning. At the end of the educational intervention, the result of the post-test indicates that fourteen children were able to advance the grammatical structure by using word classes and composing them in the order of the sentence elements, which only four of them perform according to the pre-test.

Almendral School

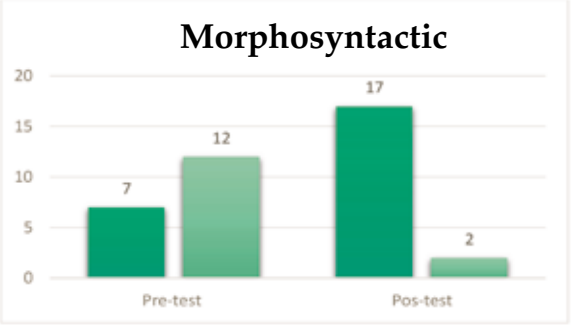
Figure 5. Results of the morphosyntactic assessment



The eighteen children who participated in the educational intervention of the Almendral School, Figure 5, advanced in the creation of sentences since only six performed it in the pre-test. At the end of the educational intervention, seventeen children were using words and artifices for the composition and order of the sentence elements in explaining the astronomical phenomena.

José Bernardo Suárez School

Figure 6. Results of the morphosyntactic assessment



Out of the nineteen children who participated in the study, Figure 6, seven structured a sentence properly in the pre-test. At the end of the intervention, sixteen used type of words and composed them in order of the sentence elements, when they explained the astronomical concepts taught.

The morphosintactic aspect involves understanding the different parts of the sentence

and the function that each one has in the total text (Díaz & Álvarez-Salamanca, 2006). According to Peterson and French (2008), children learn the linguistic components of color mixing explanations by engaging in discussions with educators and peers. In this context, the Stellarium program in simulating the movements of the Earth and the phases of the Moon allows students to explain what they are observing (Andrade, Silva & Araújo, 2009). In addition, Reinoso (2012) notes students can explore and explain their physical properties with RA and the visualization of 3D objects. Therefore, both tools allowed visual experiences to advance the construction of scientific language by communicating the observed phenomena.

Conclusions

Since Astronomy is a science that requires night observation, simulators such as the Stellarium program and augmented reality can fill this inconvenience by realistically showing the night sky, allowing children to observe the stars, constellations and solar system as they would see it at night, facilitating the explanation of celestial phenomena to the educator.

For this reason, kindergarten educators must diversify opportunities by incorporating innovative means into the teaching and learning process. Using technological resources in education is a methodological contribution and it represents a challenge in modifying the repertoire of pedagogical practices to promote creativity in teachers.

From the results obtained in the educational intervention it is noted that:

- The use of augmented reality and simulators in education has allowed to diversify teaching to improve learning. The girl and the boy is the protagonist and forger of his/her own knowledge, through his/her skills in the management of the technological resources.
- The results of the tests applied in the three schools show that the incorporation of ICT into educational intervention is a support in the learning of astronomical concepts and in the development of scientific language by the children, which is consistent with the study of Pérez-Lisboa (2017).
- The development of this educational intervention was proposed as a support tool for the study of stars and constellations. In this educational intervention, it is observed the great interest of multimedia resources in children, the great motivation they have and the enormous conceptual scopes reflected in the performances obtained and in the domain and ownership over the acquired knowledge, which is consistent with the studies of Cubillo et al. (2014).
- The contents worked with this material and the way they are presented in this educational intervention, through 3D images and simulations, generated curiosity and interest in the students to know each of the topics, allowing them to improve their performance, since they are focused on the activities they carry out, which is consistent with the studies conducted by Giasiranis and Sofos (2016).
- This research highlights the importance of this type of teaching and interactive resources for teaching-learning. Astronomy, being a science that is based on observation and especially night watching, is favored with the incorporation of these technologies for its dissemination and teaching.
- ICT is a recreational teaching medium where the teacher and the student not only interact with inanimate objects, but can generate movement, making the teaching and learning process fun and interactive. In this way, ICTs become a tool that allows to make representations to know the characteristics and attributes of the universe, as noted in MINEDUC (2001).
- With regard to the limitations of this study, the short implementation time interfered since it lasted only one semester and not two as occurred in the interventions of previous years, this was due to the little funding given

to the project, which did not allow to continue paying the teacher who was in charge.

As projections, the research team intends to continue to seek funding alternatives to continue teaching astronomy to children.

Supports and Funding

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Ethical considerations

Before evaluating the children who participated in the educational intervention, the parents and guardians gave their informed consent, and also agreed to have their photographs taken and recorded for them to be used in this article. In addition, the kindergarten teachers who implemented the project also provided their informed consent to this article.

Acknowledgment

We want to thank all the children who participated in the research, the interest in learning, the joy, the curiosity, the affection, and respect they showed, which allowed us to show that what they were doing was very important to them. To their parents and relatives for authorizing the participation in the study. To the directors, heads of the educative institution, educators of kindergartens for believing in our project. To the kindergarten educators who implemented the educational intervention. Finally, we thank the General Research Department and the Faculty of Engineering of the University of Playa Ancha, by having financed this research.

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