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Development of scientific skills: augmented reality and interactive digital board

Desenvolvimento de competências científicas: realidade aumentada e quadro digital interativo

Desarrollo de habilidades científicas: realidad aumentada y pizarra digital interactiva

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ABSTRACT

Augmented reality and interactive digital boards are tools that enhance students' learning. This study shows how 95 5-year-old children in kindergarten, from three municipal schools in San Felipe, Chile, improved their scientific skills of observing, communicating, and formulating hypotheses employing these tools. Three pre- and post-tests were applied through quasi-experimental research, and it was possible to observe the level of development in each scientific skill. The results showed that the program Experiment with Physics using Augmented Reality and Interactive Digital Board is a didactic strategy that allows the mediation between teachers and children, as well as the discovery and comprehension of some physical phenomena, enhancing scientific skills.

Keywords: physics teaching; augmented reality; interactive digital board; scientific skills.

RESUMO

A realidade aumentada e o quadro digital interativo são ferramentas que potencializam a aprendizagem dos alunos. Este estudo mostra como 95 crianças de 5 anos do jardim de infância, de três escolas municipais de San Felipe, Chile, melhoraram suas habilidades científicas de observação, comunicação e formulação de hipóteses por meio dessas ferramentas. Foram aplicados três pré e pós-testes por meio de pesquisa quase experimental, e foi possível observar o nível de desenvolvimento em cada uma das competências científicas. Os resultados mostraram que o programa Experimento de Física utilizando Realidade Aumentada e Quadro Digital Interativo é uma estratégia didática que permite a mediação entre professores, crianças e a descoberta e compreensão de alguns fenômenos físicos, potencializando habilidades científicas.

Palavras-chave: ensino de física; realidade aumentada; quadro digital interativo; habilidades científicas.

RESUMEN

La realidad aumentada y la pizarra digital interactiva son herramientas que potencian el aprendizaje de los estudiantes. Este estudio muestra cómo 95 niños de 5 años de edad preescolar, de tres colegios municipales de San Felipe, Chile, mejoraron sus habilidades científicas de observación, comunicación y formulación de hipótesis mediante estas herramientas. Se aplicaron tres pre y post pruebas a través de una investigación cuasi experimental, y se pudo observar el nivel de desarrollo en cada una de las habilidades científicas. Los resultados demostraron que el programa Experimenta la Física utilizando Realidad Aumentada y Pizarra Digital Interactiva es una estrategia didáctica que permite la mediación entre profesores, niños y el descubrimiento y comprensión de algunos fenómenos físicos, potenciando habilidades científicas.

Palabras clave: enseñanza de la física; realidad aumentada; pizarra digital interactivo; habilidades científicas.

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Integrating augmented reality (AR) and interactive boards can effectively boost young children's scientific skills like observation, communication, and hypothesis formation in real classroom settings.
Originality/value:
This study offers original empirical evidence that demonstrates the positive impact of combining AR and interactive digital boards on developing specific scientific skills in young kindergarteners. These results are particularly relevant for emerging countries and their potential improvements in education systems.

INTRODUCTION

The teaching of science in early childhood education has become very important as a result of neuroscience findings pointing out the modifications in neuronal connections, and many studies that have demonstrated the positive impact of programs implemented throughout the world. An example of this is the research carried out by Van der Graaf, Segers and Verhoeven (2018), carrying out experiments on infants stimulates their curiosity, listening, recording information and reflection. Another example is the research by Eti and Sigirtmac (2021), who analyzed the scientific education proposal based on research, the results show that, through this proposal the children actively participated and experienced inquiry skills.

Children are motivated by scientific research when they do practical activities (Jin, Yoon and Hanc, 2022), since they have a natural tendency to investigate their surroundings (Patrick et al. 2009). This natural curiosity provides an opportunity to enhance their abilities to observe, describe, group, communicate, experiment, formulate hypotheses, and ask among others. According to Areljung (2019), for this to happen, educators must carry out exploratory activities and pose simple research questions according to their everyday world. The planning of science activities should promote teaching situations at all stages: beginning, development and end; should be understandable; attractive and motivating so children can investigate with freedom and confidence, which will allow them to express their ideas openly (Trujillo, 2007).

Children's first pedagogical experiences must develop essential abilities to promote basic knowledge and fundamental skills of scientific research (Patrick et al., 2009; D'Achiardi, 2016; ALdarabah and Al-Mouhtadi, 2015). The teaching strategies explicitly guided by the teacher, which incorporate concepts of science and vocabulary are effective methods for children to ask questions, build and test hypotheses, make predictions and solve scientific problems (Honga and Di-amondb, 2012). The research carried out by Sackes et al. (2011) points out that the amount of scientific pedagogical experiences in kindergartens can be a predictor of success for learning science at higher education levels because it increases the likelihood that children will develop skills in the scientific process and basic science concepts. Therefore, teaching science when it begins in Early Childhood Education favors the formation of scientific concepts (Fragkiadaki, Fleer, & Rai, 2023), and allows them to do science in a fun way while distinguishing fact from fiction (Blanquet and Picholle, 2011). Another positive aspect is that it identifies with culturally relevant contexts and work closely with the family (Fleer et al., 2016).

Literature has shown that incorporating different ICT tools (information and communication technology), such as a computer game through the POE model (prediction, observation and explanation), allows learning the concepts of light and shadow (Hsu et al., 2011). The use of Internet technology with photo albums for Katz (2011) also makes it possible for children to explore their identity as a scientist since they consider their emotional needs. In the same way, 3DL images allowed students to have positive attitudes towards teaching and improved logical and visual thinking (Musawi et al., 2017).

Augmented reality (AR) interfaces according to researchers Düzyol, Yıldırım, and Özyılmaz "attracted children's attention more, created a greater sense of reality, and excited them compared to practicing with two-dimensional images" (2022, p. 190). The study by Huseyin and Erkan (2016), investigated AR learning and its impact on 97 students' opinions, the results show that students evaluate contents with augmented reality positively. Another study carried out by Paule-Ruiz et al. (2017) shows the use of software for learning music in early childhood education, this mobile application consists of four games that allow training the ear, the discrimination of sound and the musical composition. "The it enables concrete visualization of abstract objects, understanding of complex concepts, and a better learning experience by using spatial images, videos and sounds" (Aydoğdu and Kelpšiene, 2021, p.15), and im-prove the interest and participation (Antonia and Evgenia, 2018). AR applications are very effective tools in learning and teaching (Özeren and Top, 2023). According to Rahmat et al. (2023), AR in physics teaching makes learning more interesting, learning environments more pleasant, and helps understand complex concepts.

Similarly, Del Moral et al. (2014) point out that teachers have a strong conviction that the interactive digital whiteboard allows them to maintain the attention and motivation of their students. Furthermore, it is of great interest to students because they can observe and explain their learning interactively (Andrade, 2012). For Hernández et al. (2020), the PDI allows improving the understanding of the main topics since students have a better disposition to work in the classroom. Through this tool, a set of experiences and knowledge can be carried out to achieve the learning objectives, which improves the self-esteem of students (Rojas-Segovia and Romero-Varela, 2019).

Considering that the teaching of natural phenomena should begin in early childhood education as it promotes the development of the individuals, and that the technological tools of augmented reality and interactive digital board enhance learning, a didactics classroom is implemented on the San Felipe Campus, to teach contents of science to children of municipal schools. After several investigations, it was possible to show that this new educational space promotes learning since it provides autonomy, interrelation, motivation and collaboration among children (Pérez-Lisboa and Caldeiro-Pedreira, 2017). It is in this context that the research project with the Experiment with Physics program using Augmented Reality and interactive digital board is implemented. The purpose was to develop scientific skills to observe, communicate and formulate hypotheses.

To achieve this purpose, I know design the program based on the methodological strategy that had already been implemented in previous years and whose findings have been published. This methodological strategy has the following characteristics:

1. Three kindergarten teachers helped implemented the project.
2. Kindergarten teachers were trained to teach scientific skills and the contents of physical phenomena that were included in the program. They were also prepared to use augmented reality and interactive digital board.
3. The selection of the contents was based on the learning objectives of the Exploration of the Natural Environment core of the Curricular Bases of Early Childhood Education.

The methodological strategy used in the didactic classroom is based on the Zone of Proximal Development proposed by Vygotsky "the distance between the real level of development, determined by the ability to independently solve a problem, and the level of potential development, determined through the resolution of a problem under the guidance of an educator" (1979, p. 133). According to Moll (1990), this Zone of Proximal Development is built in conjunction with the other level - or levels - of potential development within the social and communicative plans - sensitive periods. De Corte (1990) highlights that the Zone of Proximal Development has an important educational role in the design of learning systems with technological tools, such as the computer, since it can play the part of a partner or an adult as a guide learning. The great didactic potential of augmented reality and the interactive digital whiteboard (Pérez-Lisboa and Caldeiro-Pereira, 2017) allows children to be accompanied in sensitive periods and social mediation, together with the educator and other children create favorable conditions for learning in the didactic classroom.

METHODS

This study analyzed the development of scientific skills of observation, communication and hypotheses formulation, through augmented reality and interactive digital board. In the next section, presents itself the context, participants, design and approach of the project, development of learning experiments: approach and procedure, preparation of kindergarten teachers, application of the instruments and data analysis.

Context

Initial Education in Chile, called Educación Parvularia "its purpose is to promote quality, timely and relevant education, which promotes relevant and significant learning based on the well-being, full development and significance of the girl and boy as people." (Subsecretaria de Educación Parvularia, 2018, p. 33). It provides comprehensive education for children in nursery (from birth to four years of age) and kindergarten (from four to six years of age).

San Felipe has a population of 76,844 inhabitants 3,415 of these are children from four to six years of age; 90.95% live in the city and 9.04% live in the countryside (Census, 2017). The city has two kinds of public educational establishments: municipal schools (for kindergarten and elementary education) and Lyceum (for kindergarten, elementary education and high school). Eleven of them are urban schools, eight are rural schools and three Lyceum that offer courses for kindergarten levels, which, in Chile, are divided into minor transition level (four to five years of age) and senior transition level (five to six years of age). Most children who attend these educational establishments are from the lowest socioeconomic levels in town.

Early Childhood Education in Chile follows the guidelines of the Curricular Bases of Early Childhood Education that provide foundations, learning objectives and guidelines for the pedagogical work that takes place in the classroom. To work in the natural sciences, expected learning is defined in the Natural Environment Exploration core, which aims to encourage children to develop "skills, attitudes and knowledge that allow them to understand, appreciate and care for their natural environment, enhancing their curiosity and capacity for wonder" (Subsecretaria de Educación Parvularia, 2018, p. 83).

Participants

The study involved 95 boys and girls from three municipal schools in San Felipe dis-trict: a rural school, an urban school and a Lyceum. The principals of each establish-ment with its management team and nursery teachers voluntarily decided to be part of the project.

Regarding ethical considerations, the researchers, the heads of the technical unit, and the preschool teachers presented the project to the children's families, who authorized their participation. Before traveling to the university, each child was asked if they agreed to participate. Each school was responsible for obtaining authorization from the Municipal

Secretariat of Education for the preschool children to attend university. The Municipal Secretariat of Education provided a minibus for transportation.

During the first year of project implementation, 42 children participated, between May and November 2018; during the second year, 53 children attended, between April and the first week of July 2019. Sessions were held once a week, lasting 60 minutes, and included the following activities: Greetings; Start of the learning experiment; Development; Cognitive break; Games on the interactive whiteboard; End of the experiment; Farewell.

The learning experiment began with augmented reality, a 3D image of the subject to be worked on, which improved the ability to observe (not only with the sight since sounds were added; the sense of smell, touch and taste were enhanced with children's previous knowledge). During the learning experiment, we worked with the interactive digital board, in which videos of the phenomenon, web pages, images, sounds and games were inserted. The children communicated and formulated hypotheses about the phenomenon they observed. At the end of the experiment, the hypotheses were contrasted and feedback was given on the content learned.

Design and approach of the project

According to Rubio (2014), Chile has favorable conditions for astronomical observation. In the north of the country, there are many clear nights and there is atmospheric transparency, which has led to the installation of astronomical observatories. Children are fascinated by observing the universe; it captures their imagination and makes them ask questions about the astronomical phenomena (Kallery, 2011). This natural need and curiosity to investigate the universe has motivated the search of the outer space, in an adventure of exploration and discovery to measure and interpret those phenomena that have fascinated young people (Ruiz, 2017). In this context, NASA's objectives of astronomy education for children (2003) are to awaken imagination and to stimulate interest in spatial inquiry.

Children not only like to explore the universe, but they also pay attention to the phenomena that occur on Earth. For Solis, Curtis and Hayes-Messinger (2017), magnetism, forces, energy, tension, friction and simple machines are concepts spontaneously explored by means of games with objects to make sense of the physical world. Considering what was exposed above, this project on teaching of physics was used to develop the skills of observing, communicating and formulating hypotheses in children of five years of age.

This study invite boys and girls early childhood education to the knowledge of the universe and the earth in order to identify the causes of physical phenomena, the study also "fosters the development of the observation skill, that is, the ability to obtain information about the world, perceive and discover elements, situations and / or phenomena" (MINEDUC, 2011, p. 34). This scientific ability implies that children are concentrated and use all the senses to obtain as much information as possible about the object or fact observed.

It also aims to develop the ability to communicate, that is, "expose their ideas, ask and explain their points of view or conclusions, trying to give opportunity for everyone to participate, express themselves, listen to each other and respect their approaches" (Ídem, p. 36). The children are also encouraged to record the research process through tables, graphs, diagrams and drawings. Finally, the ability to formulate hypotheses is defined as the "intrinsic ability of research, which seeks the probable explanations of a phenomenon" (idem, p. 35). The hypotheses are raised to be proven, which can be confirmed or refuted, but the important thing is that they guide the investigation into one direction.

The objective of this research is to analyze the development of scientific skills through augmented reality and the digital board. The specific objectives of the study are:

1. To determine the level of development of the observation skill.
2. To investigate the development of the communicate skill.
3. To identify the development of the hypothesis's formulation skill.

To reach these objectives, a quasi-experimental study was carried out since the scientific abilities were measured before and after program. The type of design was pre-experimental, the variables were analyzed without relating them to any type of control (Bernal, 2007, p. 67). In this context, the research focuses on a pretest and post-test design with a single group, to which the tests are applied prior to the program and at the end of the program the same tests are applied again (Hernández et al. 2014).

The quasi-experimental studies intentionally manipulate one or more independent variables (supposedly background causes) to analyze the consequences that the manipulation has on one or more dependent variables (supposedly consequent effects). In this study, the independent variable was the experiment program with physics using augmented reality and interactive digital board. The dependent variables were the scientific skills: observation, communication and hypotheses formulation.

Development of learning experiments: focus and procedures

The learning experiments were based on the premise that astronomy is a good starting point to bring children closer to science and to teach them notions of physics, geology, chemistry, mathematics and biology since some of the astronomical phenomena can be observed, such as the phases of the moon.

Figure 1. Digital whiteboard work

Source: Evidence collected by the author

The first unit corresponded to the origin and the great structures of the universe so that the children had notions on the scales of distance and time. Later they learned about the constellations, which allowed them to develop creativity and bring them closer to the different worldviews of different peoples throughout history. Figure 1 shows one of the children working on the interactive digital board. Finally, the solar system and its components were used to teach about orbits, gravity and energy, concepts that correspond to physics and chemistry.

Figure 2. Augmented reality work

Source: Evidence collected by the author

The second unit worked on the movement and characteristics of planet Earth, which allowed children to learn geological and physical concepts to understand and value the natural environment where they live. Figure 2 shows how preschoolers interact with some rocks via augmented reality.

Figure 3. Kindergarten educator

Source: Evidence collected by the author

The third unit learned about the different energies, laws of Newton and strength to foster attitudes of questioning, wonder, sensitivity, interest in conservation and care for the environment. Figure 3 shows the nursery kindergarten educator showing hydroelectric energy. The table below details the topics and its respective phenomenon:

Table 1. Summary of learning experiences

N° of learning experiment	Topics	Physical phenomenon
First unit		
1	Elements of the universe	The Big Bang Theory and formation of chemical elements.
2	The stars	Gravity, pressure and nuclear fusion
3	Characteristics of the stars	Light, temperature and light spectrum
4	Constellations Meaning	
5	Constellations Stellarium Program	
6	Solar system	Gravity and planetary movements.
7	Planets of the solar system	Temperature, color and location
8	Meteorites	Temperature, color and movements
9	Comets	Sublimation, elliptical and parabolic movements
10	The Sun	Solar wind, nuclear fusion and temperature
11	The Moon	Eclipses
12	The Earth	Gravity and solar radiation
Second Unit		
13	Earth Movements	Translation and rotation.
14	Seasons of the year	Axis inclination, climatic changes
15	The geosphere	Density, volume, pressure and temperature
16	Inner layers of the earth	Tectonic plates y seismicity
17	The air	Wind and meteorological phenomena
18	Water and its characteristics	Chemical phenomena and density
19	Water: floating and sinking	Buoyancy and Archimedes Principle
20	Water cycles	Physical states of matter
21	The tides	Gravitational attraction
22	The rocks	Erosion and temperature changes
23	Minerals	Density and crystallization
24	The reliefs	Wind and plate tectonics
25	The volcanos	Sound, changes of matter and earthquakes
Third Unit		
1	Renewable energy	Energy Conservation, Environmental Protection
2	Wind power	Kinetic energy, wind and air currents. Operation of a wind turbine
3	Solar energy	Potential energy, nuclear reactions, nuclear fusion and photons
4	Nuclear energy	Transformation of energy, nuclear fission. Radioactive elements
5	Seawater energy	Kinetic energy, tides
6	Hydraulic energy	Kinetic and potential energy, water pressure, gravity
7	Geothermal energy	Energy, temperature, pressure, geo-tectonic activity
8	Synthesis of energy	Transformation of energies
9	Force	Effect on bodies
10	Newton's law: inertia	Forces, mass straight rectilinear movements
11	Newton's law: the relationship between force and acceleration	Dynamics, Force, acceleration and mass
12	Newton's law: action and reaction	Forces pairs, direction and force senses
12	Newton's law: action and reaction	Forces pairs, direction and force senses
13	Electric force	Mass and movement
14	Project completion	

The experiment program with physics using augmented reality and an interactive digital whiteboard was born after the various investigations that have been carried out on the didactic classroom projects. This didactic classroom creates an environment with technological tools – RA and PD – and educators that attracts attention, stimulates the senses, motivation and participation of the children (Pérez-Lisbon and Candeiro-Pereira, 2017). Science learning must "consider both children's prior knowledge and facts, events and phenomena about which they want to learn, as a basis for producing and constructing new knowledge and explanations" (Pérez-Lisboa and Castañeda, 2021, p. 129).

The achievement of the results was through the project that has been implemented with the Interactive Digital Whiteboard and Augmented Reality as a teaching strategy. In the project, different learning experiences were carried out, addressing content around learning physics, with a vision of discovery and construction of knowledge in a meaningful way.

Preparation of kindergarten educator

To implement the program, the three early kindergarten educators were trained a month before starting the project; they met once a week with each researcher. First, they selected the contents of each unit and learned how to apply them with the physics graduate. Then they prepared the technological tools with the computer engineer and planned each learning experience with the early kindergarten educator.

During the project application, they met Bachelor of Physics and computer engineer fortnightly to review the contents, 3D images and software. With kindergarten educator, they met after the application of each learning experiment, the evaluation of the class and the planning of the next one were analyzed, to adjust if necessary, depending on how the boys and girls were working in the didactic classroom.

Application of the instruments

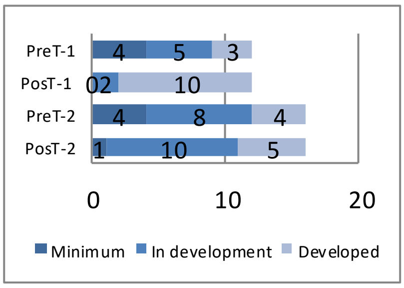
The three instruments used for this study are validated, they can be reviewed in Pérez-Lisboa and Castañeda-Pezo, (2023). Each instrument measures the development of a scientific skill, that is, the first evaluates the ability to observe, the second the ability to communicate and the third the ability to formulate hypotheses. Each instrument has three evaluation criteria: minimum level, developing level and development level.

The application of each instrument is individual, which is why before the boys and girls attended the didactic classroom, the pre-test was applied to each one and at the end of the implementation of the proposal they were evaluated with the post-test. This application was carried out by the main researcher together with the nursery educators who participated in the implementation.

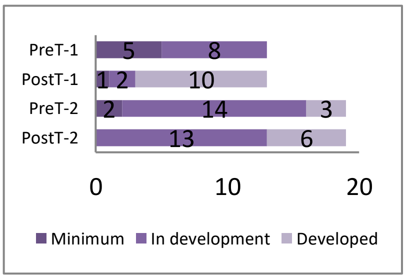
RESULTS AND DISCUSSION

The data analysis will be carried out specifying only the progress that the preschoolers had in the developed level of each skill since the comparison of pre and post test can be observed in each graph. To begin the results, we will begin with the ability to observe:

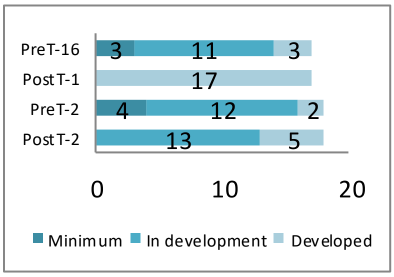
Graph 1. Lyceum



Graphs 2. Urban School



Graphs 3. Rural School

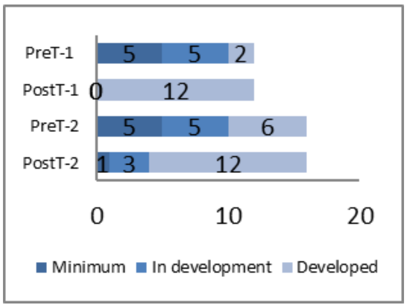


Source: author's development based on the empirical evidence collected

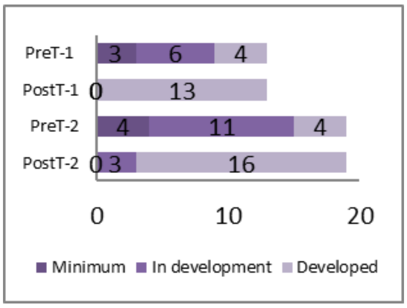
Graphs 1, 2 and 3 show the significant progress in the ability to observe in the three establishments when comparing the pre- and post-test in the first year of application of the program. In the Lyceum it was achieved that 10 children reached the developed level with 83.3%, in the urban school there were also 10 but with 77% which is very significant since in the pre-test none of them had this level and in the rural school everyone progressed to the developed level with 100% in the ability to observe. With respect to the second year of application, the ability to observe was developed in the Lyceum the children in only 5 of them with 31.2%, in the urban school there were 6 with 32%, of the children and in the rural school 5 boys and girls did it with 28% reaching the developed level in the ability to observe.

A high association strength was evident between the variables, with a contingency coefficient in the pre-test of ,707 and in the post-test of ,816.

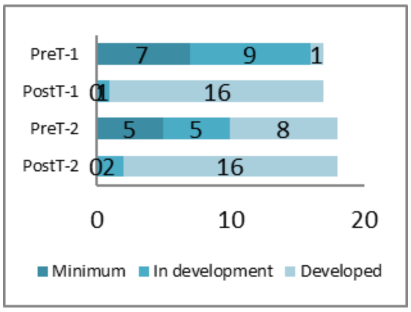
Graph 4. Lyceum



Graph 5. Urban School



Graph 6. Rural School

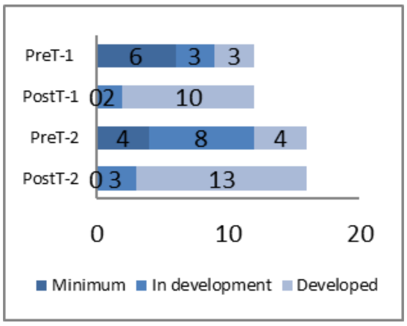


Source: author's development based on the empirical evidence collected

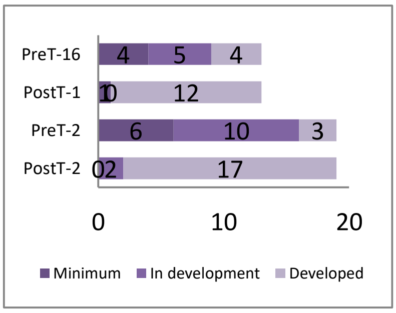
Continuing with the analysis of the results, graphs 4, 5 and 6 analyze the level of development that was advanced in the ability to communicate. In the first year of application of the program in the Lyceum, 12 children and in the urban school 13 obtained the developed level with 100% and in the rural school 16 boys and girls reached this level with 94.1% the ability to communicate. The following year at the Lyceum, 12 children achieved the developed level with 75%, in the urban school this level was reached by 16 boys and girls with 84.2% and in the rural school there were 16 children with 89% who achieved the developed level of communication skills.

A high association strength was evident between the variables, with a contingency coefficient in the pre-test of ,707 and in the post-test of ,816.

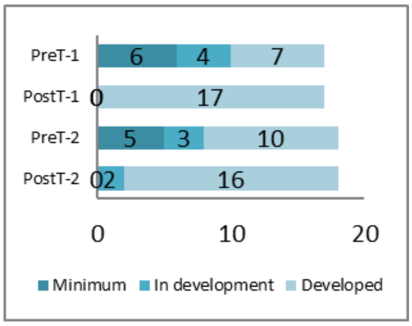
Graph 7. Lyceum



Graph 8. Urban School



Graph 9. Rural School



Source: author's development based on the empirical evidence collected

Completing the analysis of the data obtained, graphs 7, 8 and 9 show us the progress made in the ability to formulate hypotheses by the children who participated in the program. In the first year of application, 10 children at the Lyceum achieved the developed level with 83.3%, in the urban school 12 boys and girls reached this level with 92.3% and in the rural school 17 children achieved this level with 100% the developed level of the ability to formulate hypotheses. The results of the second-year show that in the Lyceum 13 children with 81.3% obtained the developed level, in the urban school 17 boys and girls achieved it with 89.5% and in the rural school 16 children with 88.9% reached the developed level of the ability to formulate hypotheses.

A high association strength was evident between the variables, with a contingency coefficient in the pre-test of ,707 and in the post-test of ,816.

Discussion

This discussion is based on the application of the physics experiment program using augmented reality and interactive digital whiteboard. The first objective of the research was to determine the level of development of the observation skill. The results indicate that there was a significant advance in this scientific skill in the first year of the project application, decreasing in the second year. To develop the observation skill, the similarities and differences of objects and phenomena must be established (Pérez- Lisboa and Castañeda- Pezo, 2023), have a lot of information about them (MINEDUC, 2011) and carry out a set of experiences (Rojas-Segovia and Romero-Varela, 2019), perhaps due to the time of application of the program in the second year, comparisons of the contents addressed could not be made. It may also have had an impact that fewer images were used with AR and more images on the interactive digital whiteboard, according to Düzyol, Yıldırım and Özyılmaz (2022), augmented reality attracts more attention of children compared to practice with two-dimensional images and improves visual logical thinking (Musawi et al., 2017).

Regarding the second objective of investigating the development of communication skills, children developed this skill in the two years of application of the program. Communicating for children is delivering information through drawings, graphs, tables and conversations (MINEDUC, online), making known what they learn (Ortiz and Cervantes, 2016). According to Rahmat et al. (2023), AR provides interesting learning environments in the teaching of physics, likewise the interactive digital whiteboard allows to improve the understanding of concepts (Hernández et al., 2020) to be able to communicate them later. Children are motivated to learn science when they do various activities (Jin, Yoon and Hanc, 2022).

Regarding the third objective of identifying the development of the ability to formulate hypotheses, children developed this ability over the two years. The interactive digital whiteboard is a tool where experiences are carried out to achieve learning objectives (Rojas-Segovia & Romero-Varela, 2019), such as the formulation of hypotheses that children developed as they raised what was happening with the phenomena (Ortiz and Cervantes, 2016) that they visualized in a concrete way through learning experiences using AR images (Aydoğdu and Kelpšiene, 2021).

CONCLUSIONS

Early Childhood Education, as the first level of education, has been playing a leading and significant role for the new generations. The solid and abundant scientific evidence reveals the importance of early childhood education. They also point out that early childhood teachers can form scientific concepts in babies (Fragkiadaki, Fleer, & Rai, 2023), and scientific skills that enhance logic and scientific thinking (ALdarabah and Al-Mouhtadi, 2015), since when researching they develop basic processes of observation, serialization, classification, use of numbers, measurement, inference and communication (Serrano, 2008).

This study analyzed the development of the scientific skills of observing, communicating and formulating hypotheses through the program of experimenting with physics using augmented reality and the interactive digital whiteboard. Although during the first year several children managed to advance to a developed level in the three skills, in the second year of implementation of the program this decreased in the ability to observe. Scientific literacy allows children to take ownership of their language and to look at the understanding of their natural environment scientifically. This understanding is the basis of scientific thinking (Van der Graaf, Segers and Verhoeven, 2018; Eti and Sigirtmac, 2021), which is developed with the scientific skills of observation (MINEDUC, 2011); communication (MINEDUC, online); and hypothesis formulation (Ortiz and Cervantes, 2016). Knowing the level of development of these scientific skills provides evidence of the learning that children obtain (D'Achiardi, 2016) and the use of AR tools (Düzyol, Yıldırım and Özyılmaz, 2022; Huseyin and Erkan 2016; Aydoğdu and Kelpšiene, 2021) and the interactive digital whiteboard (Del Moral et al., 2014; Rojas-Segovia and Romero-Varela, 2019; Hernández et al., 2020), reveals the teaching and learning process that occurs in virtual environments.

The research described in this article is a contribution to the determination and evaluation of the learning outcomes that children had in the program using augmented reality and the interactive digital whiteboard. This knowledge is a step forward in the acceptance of educational solutions in virtual environments with this type of learning. methodologies, for this reason it is necessary to consider carrying out more research on programs that use technological tools in the teaching and learning process in children in early childhood education.

In conclusion, the results obtained from the implementation of the physics experiment program using augmented reality and interactive whiteboard, provide a basis for improving teaching proposals based on these technologies.

Ethical Considerations

Before the educational intervention, parents and guardians gave their informed consent, and their informed assent was requested during the evaluation of the children

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