Strategies to Favor Integral Learning and Development Based on the Study of Physics in Preschool

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ABSTRACT
Considering the New Educational Model for Preschool Education in Mexico, a proposal is developed to favor the early stimulation of learning with the use of simple machines: balance, ramp and pulley as a means to develop preconceptions of mathematical thinking in children, incorporating play with the objective of favoring the participation of students through science, particularly physics. The experience was carried out in a kindergarten in Mexico City and consisted of a diagnosis of the children's level of development in the five fields of the New Educational Model for Preschool Education in Mexico, the design and implementation of play activities with physics content, and the monitoring of the results.

1. Introduction

Children organize their knowledge and develop their potential to learn from situations they experience in their environment, taking into account that the processes of development and learning are interrelated. According to the proposal of the New Educational Model (SEP, 2017), they must have experiences that are valuable for their present and future lives that add to their development and learning processes. This document offers the possibility of traveling new paths to make a change in the traditional way of teaching in physical science and encourages watering the seed of curiosity.

The problem of the lack of preparation in teachers in the area of science can become an engine that generates innovative opportunities to make variations and transformations in daily work in order to give more and better tools to children.

It is known that scientists organize their knowledge based on what they analyze, it is therefore possible to consider that children have the behavior of a scientist: they show curiosity, interest in knowing their environment, ask questions and make assumptions to explain what they perceive (López, 2019).

At the beginning of the twentieth century, the educational community showed a greater interest in teaching children, the Swedish Ellen Key inspired progressive educators in many countries: society began to take measures to save children by increasing the range of compulsory schooling in addition to the prohibition of work at these ages (Key, 2021).

For his part, the Swiss Emile Jean-Jacques Rousseau gave as a guideline the task of observing the capacities of children to favor their development, since one of his main ideas was to impart useful knowledge, this being the basis of education to adapt to nature, learn methods, know from the physical exploration of objects and intuition (Sononscher, 2021).

The Italian Maria Montessori was one of the people who most influenced early childhood education thanks to her innovative contribution. Through her practice, her curiosity and her professional creativity, she came to the conclusion that children "build themselves" from the stimuli they encounter in their environment. He kept in mind that children do things by themselves, use simple materials, and observe their environment paying special attention to things that grow such as plants and animals, their mind is open to science in a natural way. Everything they observe is an incentive to their innate creative intention (Martínez & Sánchez, 2010).

On the other hand, Jean Piaget, a Swiss psychologist and pedagogue, of whom we know for the application of his theories in relation to science that was based on what is called learning by discoveries: the participation of the student in his own teaching-learning process must be provoked and stimulated as long as he is provided with the tools and the necessary procedures to do so (Sánchez, 2019).

The capacities of each child represent a guide to strengthen the intervention processes that intend to enhance their skills and knowledge when facing them in everyday situations in schools. In the stage that includes two to six years, the activity of children in front of the environment that surrounds them shows creativity and accounts for the consolidation of different skills acquired in the first months of life. Based on these premises, the teacher must take into account that each child is a subject who solves situations and extracts information from his environment, in this sense early childhood education presents content with a high orientation for children to live experiences, that is, they are focused on "doing" (Bravo & Gormaz, 2023).

To achieve the objectives set in the different areas of preschool education, there are resources such as play, the use and production of didactic resources and collaborative work, all this together promotes the development of critical thinking and opens the doors to design environments and situations that serve to create an environment in which the child will be able to develop his creativity as a born inquirer (SEP, 2017, 2019).

The work carried out in Mexico in preschool education until 2022 was governed by the "Key Learning for Preschool Education" (SEP, 2017), organized into training fields, areas of development and areas of curricular autonomy. The approach to science was made through the academic training field "Exploration and knowledge of the natural and social world" which proposes the promotion of the development of curiosity in children, imagination and interest in learning about themselves, in addition to learning from the people with whom they interact and the places where they are present. The purpose is to facilitate reflective thinking through the development of skills and attitudes.

It is highlighted that the participation of the students is considered to each one as part of a group and therefore the intention is given to a joint learning where it is considered that social constructivism prioritizes relationships with other individuals in order to learn. Teachers must take care of and promote socialization because it is in the organization of the classroom, of the times, in the informal situations and in the different interactions of the children where we can obtain a guide of their motivation. These situations offer an integrated approach to knowledge, globalizing the areas offered by the curriculum (Muzás & Blanchard, 2020).

The objective that is set according to the first fruits of science research with children is to develop and apply a school work plan that promotes early stimulation for the formation of notions of the curricular axes of "number, algebra and variation", as well as "form, space and measurement" through familiarization with elementary physics content in children in the first grade of preschool.

2. Methodology

A quantitative-qualitative approach was used in this research (Hernández-Sampieri & Torres, 2018). The proposal is carried out by observing and recording for eight months in sessions 3 times a week of 45 minutes to observe the process in which the scientific thinking of preschool children is favored.

With the intention of promoting the development of comprehensive learning from physics in first-level preschools, the practice was carried out in a kindergarten in Mexico City. The research arises from the need to explore new areas and face challenges in teaching practice that allow knowledge to be used beyond school. The introduction of physics content in preschool is proposed through activities that allow children to become familiar with nature.

A mixed methodology is used that combines the collection, analysis, and correlation of quantitative and qualitative data to address the proposed problem question (Hernández et al., 2006). According to Samper (2013), this methodology, described as "the convergence of approaches", allows both quantitative and qualitative processes to be applied to the data collected, analyses carried out and conclusions obtained, with the aim of obtaining a more precise view of the phenomenon investigated. The mixed approach offers greater breadth and depth in research.

In the context of this study, quantitative data were obtained from experimentation that assessed the cognitive abilities of the participating children through rubrics, providing data of great importance to reach relevant conclusions. These quantitative data are complemented by qualitative information obtained through observation through field diaries and photographs. This approach allows for a detailed recording and reconstruction of the experiences of pedagogical activities with children that lead to relevant conclusions of the study, including interactions, verbalizations, emotional expressions, attitudes, motivation, and other indicators of participation.

This research employed a single-group experimental design, which included measurements before and after the intervention. The cognitive abilities of the participating children were evaluated both before and after implementing a pedagogical proposal for the application of physics as a means to teach notions of mathematical thinking. This design facilitates the identification of changes in children's cognitive skills attributable to the pedagogical proposal and their participation in the activities carried out. At all times, the development of pedagogical activities was promoted in classes with simple machines, so that children would only be exposed to this new methodology in that curricular context.

To work on this project, the protagonist role of the children in their education is given, activities were designed in which they had the opportunity to play with simple machines (pulley, scale and ramp) for eight months, time in which they had the opportunity to carry out planned activities oriented towards the acquisition of knowledge to begin to build notions, particularly mathematical thinking, which will be useful in future situations.

Shepard et al. (1998) cited by García and Pedroza (2022) indicate that: the requirements of reliability and validity are the least demanding of all purposes. These can be informal evaluations during teaching. More formal assessments, conducted to improve learning, should be linked to the preschool curriculum and have clear implications for what to do next. To do this, teachers must know the typical progression of children's competencies and be familiar with age and grade expectations to recognize early, below, or in accordance with expected performance.

With the resources offered by The New Educational Model, the planning, organization and evaluation of learning processes is oriented, with the teacher being responsible for the selection of the knowledge and topics that she presents to her students to achieve, in a comprehensive way, the expected learning of each axis according to the needs of the children. there are no previously established rubrics. These rubrics were created taking into account the expected learning established by the New Educational Model (2017), which are a tool that allows teaching to be adjusted and timely feedback to be provided.

The activities evaluated are characterized by having a project approach based on an experiential, situated and authentic practice and with this they learn to do and reflect from what is presented in each context. Learning projects open the doors for activities to be proposed that awaken children's sensitivity to the needs of our world while respecting their own perspective. In addition to this, the development of emotions, the channeling of the energy they possess, as well as the orientation of their interests and motivations that develop a sense of commitment to their own world are enhanced (Muzás & Blanchard, 2020).

At the end, a comparison was made of the evaluation prior to the activities focused on scientific development and the evaluation at the end of the eight months of scientific practice with the simple machines (pulley, ramp and balance), thus achieving the conclusions presented in this document.

3. Results

The selection and introduction of physics content as a way for the early stimulation of integral learning and development

Today, science and technology find in physics a means to explain the world in which we live. Physics is a science that shows us the world and the nature of things, it is not about the accumulation of concepts and finding solutions to complex numerical problems. Learning involves the development of skills to observe and assess the situations that are experienced (Corni & Fuchs, 2020).

This learning must be accompanied by experimental practice and an age-appropriate discourse so that learning is accessible, with the intention of promoting the development of skills that, gradually, build a clearer knowledge of the nature that surrounds us and its phenomena (Hernández & Veloza, 2018).

Gur (2011) considers that the value of teaching physics to children does not lie in teaching scientific concepts, principles or explanations, but rather to give children opportunities to act on objects and see how they react to build the foundations of physics. Thus, they can know their properties by making a "simple abstraction" from the information according to the perception of the senses.

When working with physics, the teacher must observe the attitudes of the children, their interests, identify the way they solve problems, how they intuit what can happen, the organization of their ideas and the way in which they obtain data, these observations tell us about the autonomy they have to inform themselves which promotes that they acquire a vision that leads them to question the nature of things. Teachers should guide children to defend their argumentative positions based on experimental work. Inquiry involves the use of critical and logical thinking in addition to the consideration of alternative solutions to the same situation (Sosa & Dávila, 2019).

Science in preschool should be an essential part of the activities that stimulate children's knowledge because it supports the construction of opinions as well as decision-making, which is why its cultural character and importance in a large number of situations in daily life is determined (Daza & Quintanilla, 2017).

As children face different situations, they learn to discern the information that is relevant gradually according to the stimuli they have. The educational intervention must strengthen the capacity for observation, the ability to question to promote description, the ability to make comparisons, to foster the spirit of inquiry, the ability to make generalizations from repeated experiences, in addition to forming the discipline of recording the information obtained to follow up on their experiences.

Vygotsky shares in his research reflected in the book Thought and Language the experiments carried out by Ach, a Polish-American psychologist, which show that the formation of the concept is the product of a creative process and not of a mechanical and passive one (Vygotsky, 1995). A concept arises from a communicative need and with the intention of sharing ideas and is built while a complex operation is developed that takes direction towards the resolution of some situation or problem where it is necessary to consider that despite the existence of the conditions of the environment for there to be a mechanical link between the word and the object, it is not a determining factor for the production of such a concept.

From this statement, it can be inferred that words can be useful as means of communication even before reaching the level of the concepts characteristic of fully developed thought (Vygotsky, 1995).

Thanks to the observation skills that are developed with school activities, guidelines are given to the creation of predictions, inferences or explanations about different factors that help them to understand the information they are organizing in their mind and with this gives rise to the formation of a base that allows them to build concepts, knowledge and attitudes to continue learning the sciences (SEP, 2004).

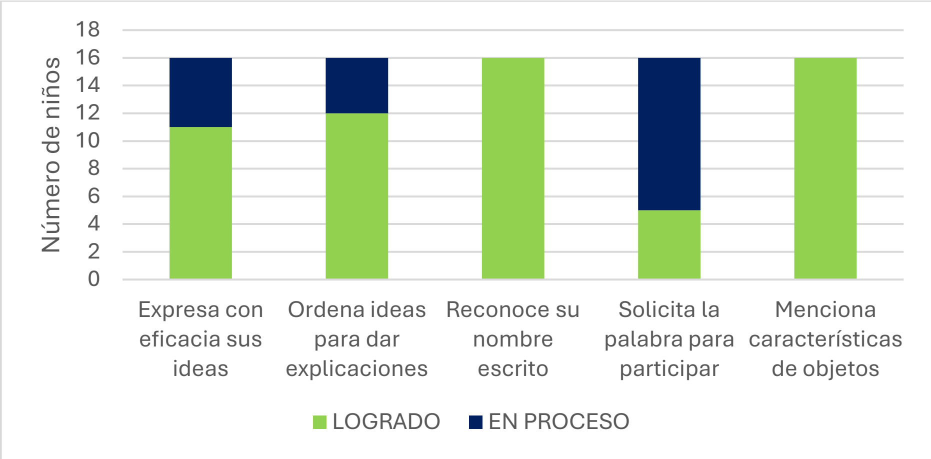
Mathematical thinking is another of the fields of the New Educational Model for preschool education (SEP. 2017), it is a gradual process and develops according to the environments to which students are exposed to organized activities that allow them to think about numbers and use them in meaningful contexts. The approach to mathematics aims to develop skills and abilities, acquire habits, and learn the first numerical concepts that lead to expecting a level of success in cumulative and significant learning (Espinoza, Reyes, & Rivas, 2019).

In order for children to work on the early stimulation of the physical scientific notion, they are offered the opportunity to use the scale, the pulley and the ramp with which the intention is given to the development of skills (classifying, analyzing, inferring, generalizing and abstracting, in addition to strengthening different types of thinking: logical, inductive reasoning, deductive and analogical) so that they can understand numbers, make use of them, begin to make estimates of distances and collections. The understanding of fundamental mathematical concepts will have as its goal that students take ownership of contexts with actions of identification, approach and problem solving. Teachers must focus on how the development of the activities is carried out, they must consider, more than the result, the procedure that the students follow to solve the problems.

Initial diagnosis of the development of the children with whom the experience was carried out

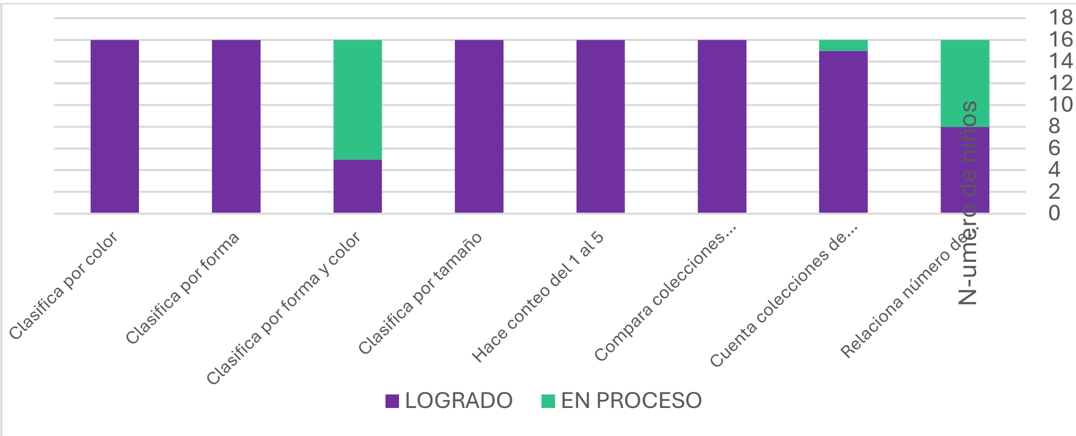
Prior to the introduction of the activities described, with the use of simple machines as ways to stimulate learning and development through the introduction of physics content, the children's level was diagnosed. The results achieved are described in graphs 1, 2, 3 and 4.

Figure 1. Result of the diagnostic evaluation checklist of Language and Communication. (Source: own elaboration). In original language Spanish



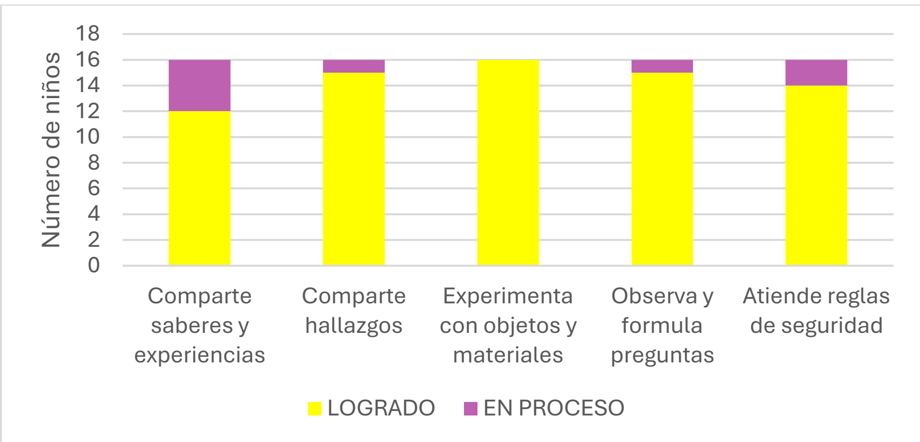
In the language area, a construction process is observed, they name and describe known objects, ask about objects and incorporate new vocabulary to identify what is in their environment. They have a hard time asking for the floor, they interrupt the speaker and they do not listen to the ideas of others.

Figure 2. Result of the diagnostic evaluation checklist of Mathematical Thinking. (Source: own elaboration). In original language Spanish



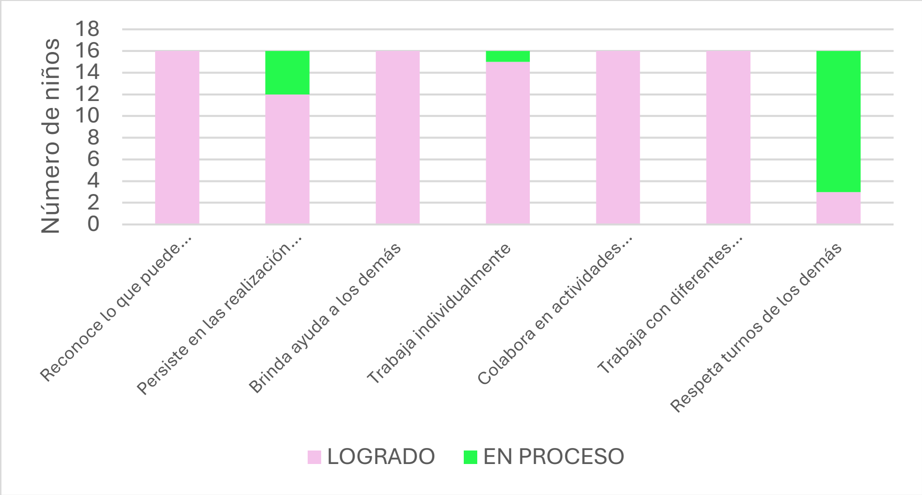
In mathematical thinking, it is emphasized that they classify objects considering a characteristic (color, shape or size). They say in a stable way the numbering from 1 to 5, but they do not know which number to assign to a given set.

Figure 3. Result of the diagnostic evaluation checklist of Exploration and knowledge of the natural and social world. (Source: own elaboration). In original language Spanish



Children share their experiences and ideas according to their daily observations and experiences. They talk and are interested in different topics. They like to experiment and use new materials. They ask questions to clarify their ideas and expand their knowledge.

Figure 4. Result of the diagnostic evaluation checklist of socio-emotional education. (Source: own elaboration). In original language Spanish



They are willing to carry out the activities, some require more accompaniment and motivation. They work individually, it is difficult for them to organize themselves in groups and they do not always accept the roles or the turn of participation of their colleagues.

Description of the experience carried out

The children experimented on a seesaw, seeing the behavior of their own body (they all wanted to be "the heaviest"), (see figure 1). They then organized packages of different materials to make qualitative comparisons with the scales. They determined that with the heaviest objects the balance tilts downwards and with the light objects the scales are up.

With collections of the same material, considering the numbers from 1 to 10 (see figures 2 and 3) they compare and choose where there were the largest number of objects. With the same ideas, they use number cards and a table to choose the set with the highest or lowest value (see Figure 4).

After several sessions, the children combine collections. By counting the total number of objects, they check the result with the scale, beginning to build the basic notions of the addition process (see figures 4, 5, 6, 7 and 8). They used symbols and images when making the comparisons (Figures 7, 8, and 9).

Figure 1. Selection of materials to work with the balance.

Figure 2. Comparison of materials that are checked with the balance.

Figure 3. Children determine which animal is heavier based on its position on the scale.

Figure 4. Worksheet in which they decide which animal is heavier or lighter according to the position of the scale.

Figure 5. The children check on the scale which number is higher or smaller.

Figure 6. Quantitative comparison on the scale.

Figure 7. Comparison of materials using symbols and images.

Figure 8. Comparison using numbers and symbols.

Figure 9. Aggregating operations that are checked against the balance.

Using the ramp, they observed toys roll and explain why there are objects that do not. They record their prediction data and their checks when using different objects.

With numbers on plastic blocks (see figure 11), they order the numbering from 1 to 10. You can see how far the toy they chose progresses. While one child rolls his toy down the ramp, another child records on a graph (see Figures 12, 13 and 14).

Figure 11. It is counted until what number the toy truck arrived after throwing it down the ramp.

Figure 12. Measuring distances using unconventional measurements.

Figure 13. The children graph the distances traveled on the ramp.

Figure 14. Recording of distances traveled with different toys (balls, carts, cylinders).

Now there is a challenge to demonstrate their strength by carrying some materials: cotton, water bottles, balls and beans (see figures 15 and 16). They all experimented with loading the different materials (see Figure 17). To offer a different way of loading, they were presented with the pulley. With a ruler on the side of the pulley, they see their progress when loading bottles (see figure 18).

Figure 15. They filled a bucket with balls to determine if it is heavy or light when using the pulley.

Figure 16. They filled the bucket with beans to determine if it was light or heavy when loaded with the pulley.

Figure 17. They checked how much they could carry.

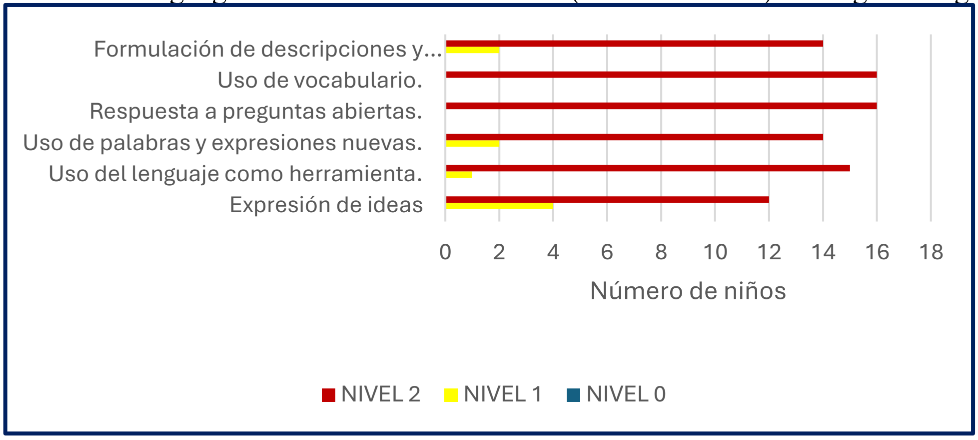
Figure 18. Measurements of distances traveled when loading water bottles using the pulley.

Loretto	10	10	10	6
Alondra R	2/10	3	1	
Luca	10	10	10	8
Máxima	10	10	7	4
Pablo	10	10	10	7
Renata	10	10	10	—
David	10	9	10	10
Yenevith	10	5	8	—
Alexa	10	10	10	—
Sebastian	10	10	7	—
Alondra F	10	10	10	—
Leonardo	10	10	9	8
Emilie	10	10	9	5
Ximena	10	10	10	10
Nicolás	10	9	8	—
Kael	10	10	10	10

Final evaluation of the proposal

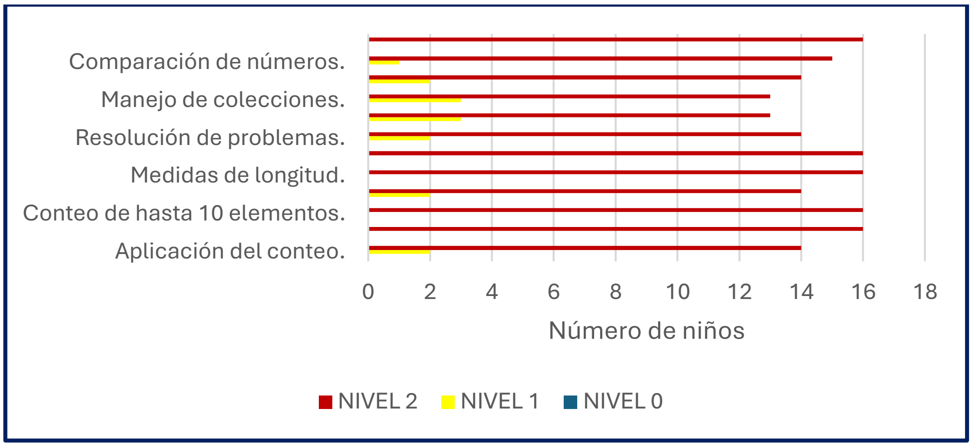
After eight months of working with the simple machines, they show more confidence to express their ideas, they organized themselves to share what they learned. As the days go by, they use clearer and more structured language when explaining what they thought, even with body language. The questions were no longer only to the teacher, but they were looking for answers among themselves. They ordered their ideas, made predictions, explained, dialogued, agreed, organized numbers and helped each other when they had a mistake. They acquired terms such as balance, strength, light, major, minor, far, near, pulley, scale, ramp, etc. (see graph 5).

Figure 5. Result of the Language and Communication rubric (Source: authors). In original language Spanish



In the area of mathematical thinking, as they were the ones who prepared the material, they began to acquire the order of the numerical sequence in a natural way (from 1 to 10) and not as a rote process. By making qualitative comparisons, they determined whether there were more or fewer elements in a collection using the symbology of "greater or lesser what" (see Figure 6).

Figure 6. Result of the Mathematical Thinking rubric (Source: own elaboration). In original language Spanish



They use the terms "greater and lesser what" when making comparisons.

They joined two collections and placed them on one side of the scale, they counted the total of elements and the resulting number was considered to put a set of that amount on the other side of the scale, if the balance was achieved it translated into the result being correct. With this, the notions of the mathematical operation addition are established.

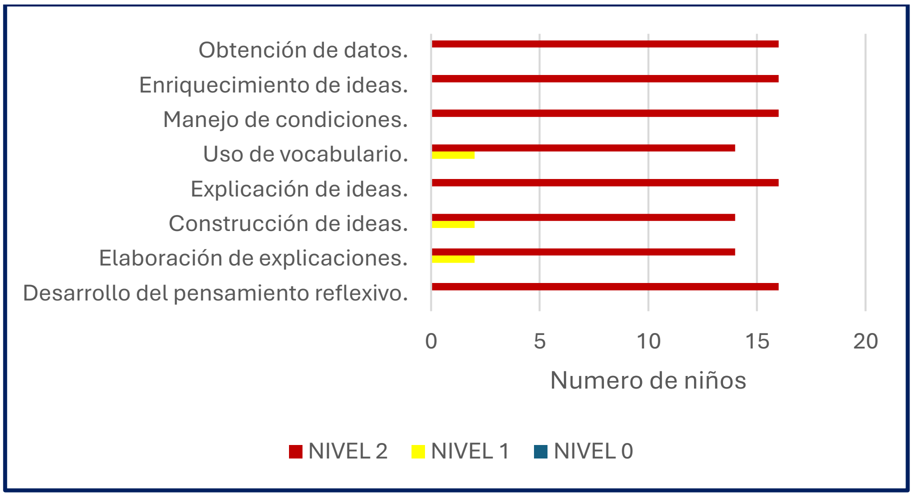
When using the ramp, they organized the numbering from 1 to 10. They chose different toys and recorded the information of the route in graphs. In addition, they analyzed how many had traveled the same distance, who had advanced the least, who had gone the farthest, how many reached X number, etc. This is how they highlighted important information they obtained.

As for the use of the pulley, when manipulating different materials they identified what was heavy or light. With a side ruler on the pulley, they saw their progress when loading and recorded their information.

The use of each machine brings them closer to physics with simple discovery events, which favors scientific development in their academic training.

In relation to the exploration and knowledge of the natural and social world, they showed enthusiasm for using simple machines and felt confident in sharing their observations. They analyzed what they were doing and their answers were more accurate. They shared opinions and explained the reasons why something worked or not. They were looking for solutions together. They learned to collect information, which served as part of the continuous evaluation (see Figure 7).

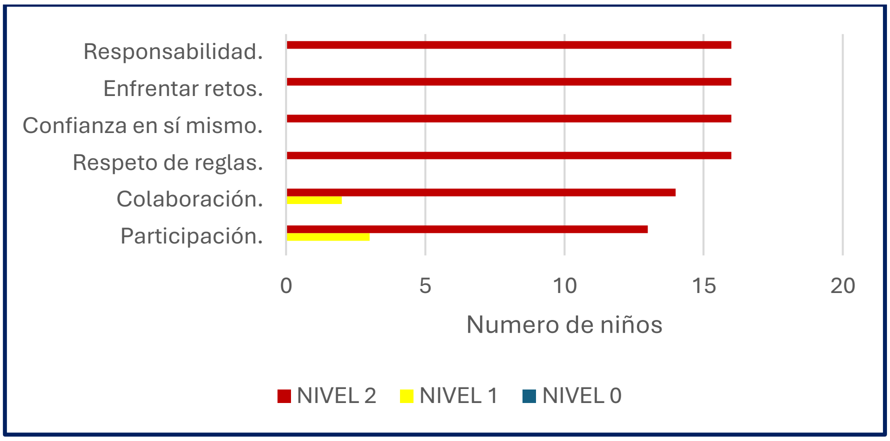
Figure 7. The result of the rubric of exploration and knowledge of the natural and social world. (Source: own elaboration). In original language Spanish



The results of the activities in emotional education were motivating because everyone was acquiring roles and helping each other. They respected the turns, they did not fight to be the first and there was more organization working in teams and in groups, to listen and accept the opinion or ideas of others and if there were mistakes, they looked for alternatives. There was commitment and fewer distractions.

Physical activities are a challenge, so you definitely have a reason to provoke curiosity and the desire to get to know your surroundings (see graph 8).

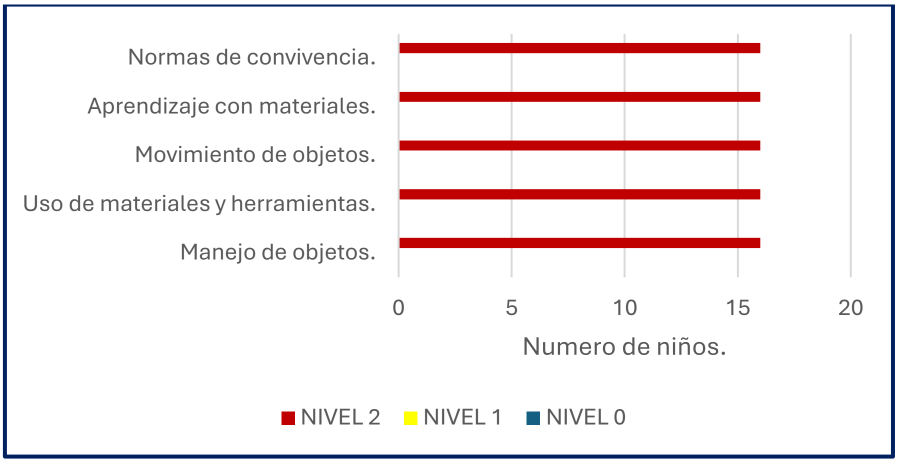
Figure 8. Result of the socio-emotional education rubric. (Source: own elaboration). In original language Spanish



They learned to manipulate, care for and order the material, identifying its function, respecting the purposes for which it was being used.

The movement in the classroom taught them to organize themselves by being more cooperative, doing activities with a purpose. By motivating their interest with science activities while playing, children develop attitudes of greater attention and participation following the established rules for a better coexistence.

Figure 9. Result of the Physical Education rubric. (Source: own elaboration). In original language Spanish



4. Conclusions

This project, where physics has been used as a means of learning and the development of skills and attitudes, draws a very different perspective from what traditional science work is in the classroom. The scientific training of children contributes to knowing their environment and bringing reality closer to school, which allows expanding the didactic situations that arise, so the teacher has to implement new strategies to achieve their mission in teaching science at the preschool level (Castillo, 2019). Science can be very useful to achieve the purposes that are had with respect to the two training fields to which the most importance is given, which are Language and Communication and Mathematical Thinking.

Comprehensive training has been successfully achieved, as the children have acquired an active attitude, cooperation and solidarity with their classmates, respect and sharing materials. They were curious and enthusiastic. They built opinions and knowledge. The learning was achieved in the different training fields proposed. Physics enriched the classroom and the development of each child, changing the class scheme: they learn from observation, experimentation and the orderly follow-up of activities, which highlights their participation as little scientists.

Early stimulation with the use of simple machines, scales, pulleys and ramps have allowed children to be introduced to the knowledge of numbers from their use through counting activities, recording data in graphs, measuring distances, comparing quantities, always having the slogan of participation of the children, achieving a natural use of the concepts, thus changing their way of assimilating cognitive terms from their own logic and its level of development.

Science education for the preschool stage in this project was based on didactic methods favoring the development of scientific skills such as classification, experimentation, hypothesis formulation, inference and planning. This is achieved through the protagonism of each child in scientific experiences and games that reinforce their critical capacity, reasoning, argumentation and creativity with early stimulation.

This narrative of the work carried out must be considered as a positive response, concluding that working in the fields of Language and Communication and Mathematical Thinking with a scientific perspective has favored the integral learning of the students, achieving the proposed skills. At the same time, the importance of making science a means to offer more opportunities to strengthen their cognitive, motivational, creative development and an open attitude to a scientific context is highlighted.

As a teacher, I emphasize that our role as builders of didactic situations and environments promote the acquisition of significant learning, being certain that, although it is a challenge, it is possible to have an approach to science through early stimulation, opening possibilities and establishing actions that give guidelines to explore this option from preschool ages.

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