Teaching Physics at Preschool Level for Mexican Students in order to achieve the National Scientific Standards

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Abstract
In its program of studies for preschool level, the Secretary of Public Education of Mexico promoted development of four standards of science: Scientific knowledge, applications of scientific knowledge and technology, skills associated to science, and attitudes associated to science. However, to develop this skills and reach out the standards there are some problems; one of them is lack of specific syllabus that allow to the teachers since a concept develop the skills needed to reach out the four standards in science. In this paper we shows the results of use physics concepts (specifically electricity) to build skills aimed to reach the standards of science in children of preschool level. We implemented an inquiry cycle that include generation questions, abstract conceptualization, demonstrative experiments, handling of experimental kits and a link of the experience with the real world, all around of concept of electric charge. We find finalizing the cycle that the kids achieved acquisition of a basic science vocabulary, developing of a greater capacity to interpret and represent natural phenomena and link of scientific knowledge with their environment, skills request to reach out standards of science in preschool students in Mexico.
Keywords: Preschool Physics, Science in school, Teaching methods and strategies

Introduction

As the Political Constitution of the United States of Mexico refers, the education in Mexico is consecrated. The General Law of Education in Mexico forces those who reside in Mexico to attend at least the levels of Elementary, Middle, and High school; it also establishes that the parents have the responsibility to verify that their children accomplish it with nice support. The educative service for the girls and boys under six years old is essential to grant their optimum formation and development; this educational service or formal education is based on the Mexican Educational System, whose levels include: Initial Education, Basic Education (Preschool, Middle, and High School) and Higher Education (University Level and Technical).

The Initial Education brings an education service for boys and girls less than six years old, with the purpose of increase their integral and harmonious development in an environment rich in formative, educational, and affective experiences, which would help them to acquire abilities, habits, values, as well as to improve their autonomy, creativity, an necessary attitudes, in their personal and social performance according to The Public Education Secretariat (SEP its acronym in Spanish). Given the above, this paper intends to take one of the intentions expressed in the Initial Education and develop it on the level of Basic Education, particularly on the Preschool Education due to the importance that these early years of life have in the formation of the individual, to work in favor of childhood so they can have knowledge, skills, habits, and attitudes consistent with the rapid evolution of everyday life.

In Mexico, Preschool Education consists of three degrees, student starts his education at three years old, and generally graduates at the age of five or six years old. It is governed by the Preschool Education Study Program 2011 (PEP 2011, its acronym on Spanish), this one is national in all the modalities and preschools, on public or private support. This contain several formative fields, one of them is Exploration and Knowledge of the World. Unfortunately, in this level, the formative field Exploration and Knowledge of the World (and the two aspects in which they are organized: natural world, culture, and social life), teachers suffer lack of methodological guidelines and contents to transmit it to the students, particularly related to the physical phenomena, and therefore students can't reach the standards proposed by the SEP in the PEP 2011 standards (Ramírez, Nieto and Ruíz, 2014).

As mentioned, the PEP 2011 contains curricular standards to cover at the end of the preschool cycle in which science standards are highlighted. Inside the science standards are considered the exploration and knowledge of the world, which in turn presents (SEP 2011):

Submit a vision of a population using knowledge associated with science, which provide them with basic scientific training at the end of the four school periods. They are presented in four categories:

1. Scientific knowledge.
2. Application to the Scientific Knowledge and Technology.
3. Science Associated abilities.
4. Science Associated attitudes.

The progression through the Science Standards has to be understood like:

- The acquisition of a basic vocabulary to advance on the construction of a scientific language.
- The developing of a greater capacity to understand and represent natural phenomena and processes.
- The increasing linkage of scientific knowledge with other disciplines to explain natural phenomena and processes and their application in different contexts and situations of social and environmental relevance.

However, a big number of teachers of preschool level have not instructional materials to address these four categories. There are efforts to bring the teachers, both, material and training, to improve their skills in science that eventually enable them to reach their students the required standards in science, example of this is the work done by Dr. Cecilia Stari from the University of the Republic of Uruguay or works done in Spain and even work done in Mexico (Rodriguez & Botello, 2011). On the other hand, there is a growing line of research that seeks to develop learning themes of sciences (especially physics) on the basic levels, even on preschool. Proof of this, are the papers presented at the World Conference on Physics Education 2012 by several authors (Starci, Onderova, Susman, Goldberg, Mohd, 2012).

In this paper, we show the results to build and implement a cycle of inquiry in preschool level, in order to achieve the science standards mentioned above. In particularly, here are found that the kids achieved acquisition of a basic science vocabulary, developing of a greater capacity to interpret and represent natural phenomena and link of scientific knowledge with their environment, so previous ideas showing to the little ones about the electricity and its origin.

Methodology

Tonucci (Tonucci, 2006) discusses the preschool as a stage where the child builds the foundations in which all the cognitive, social, emotional conditions of his entire life are developed. The preschoolers require family and environmental favorable conditions, i. e; Transmit them affection, provide them food enough, hygiene; and in school, kids should learn to be together, to coexist with their classmates, to share emotions and experiences, to express themselves through language, to observe the reality, to be stunned by new things, to look for answers, to listen, and to work together.

Tonucci comments that in the field of the science, schools should allow the kid the contact with the nature and the biological objects, from these and other experiences is expected that the child learns to observe, to listen, to formulate his first hypotheses, to compare them with those of his peers, to take a risk on early theories, to recognize them overcome, etc.

It is important to mention that Tonucci participated in drafting the SEP Actualization Workshop Guide and made contributions to the Training Field and World Knowledge Exploration in the guide for the Initial Education Program 2011.

A way to try to aboard this formative field is to begin with an inquiry cycle. This kind of cycle is a regular thing in some schools of preschool level on Mexico, in particularly, seen from the point of view of Katy Short's proposal (Short & Lazzarino, 2000). This inquiry cycle has some general characteristics that allow to be implemented in practice almost every topic, on figure one; you can see in a general way its particularities:

INQUIRY CYCLE		
Steps (recursive)	**Description**	**Teacher's rol**
▪ Building on the known (prior knowledge)	▪ The relationship with our life experiences ▪ Students gather information and share it in pairs. ▪ Family stories and experiences. ▪ Interviews. ▪ Timelines. ▪ Objects related to the subject (helps them build relationships and facilitate oral expression.	The teacher must listen to grasp the meaning of the relations and the children's opinions.
▪ To take time to find questions for inquiry	▪ Slow movements ▪ Take the time to: look, listen, smell, see, discuss and formulate questions about the world. ▪ The importance of examining materials and formulate questions for inquiry. ▪ Gather facts and interesting ideas and warn contradictions. ▪ After examining the materials, students informally record their observations and questions with drawings and / or essays in diaries to facilitate the sharing. ▪ Explore materials and share. ▪ They elaborate conceptual networks that will enrich. ▪ They can produce graphs of general inquiry where they could record all questions continuously. ▪ Here's a process of observation, conversation and selection for development of questions is given.	Incorporate a wide range of perspectives on the subject. (bringing different materials, information sources focused on topics of interest) Stablish exploration centers (select topics from a box).

▪ Aquire new perspectives	▪ Examine your questions. ▪ Learning environments that support the information. ▪ Diversity of resources related to children's questions. ▪ Form groups of 4 to 5 children depending on the topic of interest. ▪ Develop a plan for the inquiry. (can be in reading and discussion circles, field studies, collect resources like videos, recordings, music, visits, interviews, reflective drama, related topics that may be included in the corners of exploration toys, etc.)	▪ Encourage them to form groups so they can share information and learn to think together. ▪ Teachers and students gather the materials. ▪ Plan with all the class activities that can work as a reference to the inquiries of the smallest groups. ▪ Read books and stories aloud to small groups.
▪ To take care of the difference	▪ Have time to draw or write in their journals of inquiry, reflection records or records of learning, in order to develop ideas.	▪ Provide times of quiet, silent places, isolated from the group to think and to consider their ideas.
▪ To share the learned.	▪ Gather their ideas to formally present them to their peers. ▪ Through the presentation, they modify their knowledge and their classmates. ▪ Presentations pose no end, but provide an opportunity for children to determine they have learned and share it with others. The presentations may vary: Books, compositions, pantomime, theater, choral readings, murals, songs, operas, masks, exhibitions, oral presentations, paintings, sculptures, musical compositions, graphic organizers, etc. All depending on the type of audience that will listen to them.	▪ Develop with the students a list of what they believe is most important and choose the type of presentation that best suits the information presented.
▪ To plan new inquiries.	▪ The more you involve longer need to reflect on what they know, how they learn and why to inquire. ▪ They get to know during process what tools and resources they are occupying and can be used in other contexts and their own personal life. ▪ Review the list of questions and think through free essays, records, etc. through the reflections they set new inquiries.	
▪ Emprender una nueva acción reflexiva.	▪ El proceso de indagación nunca llega a su fin. ▪ A veces se termina la experiencia con una serie de nuevas preguntas, que a su vez se convierten en la base de nuevos temas de indagación. ▪ Se discute el rumbo de una nueva indagación y se elabora nuevamente una lista de posibles temas asuntos y preguntas. ▪ Se puede regresar al centro de exploración sobre el concepto general facilitando la nueva indagación.	

Figure 1. *Inquiry Cycle by Katy Short*

As mentioned in the introduction to this paper, the teaching of science and particularly the training field Exploration and World Knowledge is usually not develop because teachers have little content development and methodological guidelines for transmit it to the students, despite having a valuable tool as the cycles of inquiry that also tend to handle properly in other educational fields.

On the other hand, in the area of general science education and physics in particular, there are examples of similar cycles of inquiry that have shown success in learning especially in high school and college levels methodologies, such is the case of Teaching Models of Needham (Needham, 1987), Sanmarti (Sanmarti, 2002), Gomez (Gomez, 2003), including Mexico's environment have made some effort, but the previous aimed specifically to high school and college levels (García-Salcedo and Sánchez, 2009, Ramirez, 2010).

In this study, we sought to unite both experiences, i.e., the construction of a cycle of inquiry aimed at showing in small notions of physics, specifically electricity to the training field Exploration and Knowledge of the World to preschool kids.

However, it is not enough with only the construction of the inquiry cycle; it must be immersed in an educational model to its implementation and evaluation, as well as being consistent with the standards required in this case by the SEP. In this research, the proposal is applied in a private preschool in Mexico City, in which it works with the educational model International Baccalaureate (IB). In the definition of IB, is mentioned that "the aim of all IB programs is to develop internationally minded people who, conscious of the condition that connects them as human beings, and the shared responsibility to contribute for ensuring the planet a better and peaceful world."

This goes in line with the goals of comprehensive education supported by the Training Field Exploration and World Knowledge from physics concepts that is intended in this work. IB model (despite the name) is applied from preschool teaching to higher levels, so it does not conflict with the educational level studied, in this case, preschool. The IB model encourages important features to be developed in students and referred in activities designed from the cycle of inquiry, such as looking for the kids to be:

- Inquirers
- Informed and educated
- Thinkers
- Communicators
- Principled
- Open-minded
- Solidarity
- Bold
- Balanced
- Reflexive

These linked notions of physical characteristics are in direct line to achieve the science standards proposed by the PEP 2011. From the points above – The Inquiry Cycle and International Baccalaureate Model- was realized the planning and implementation of activities performed directly in the classroom. The application was made in a group of 17 kids in a preschool in Mexico City, in May 2014. Children are at an age range of 5-6 years and are in the last preschool level (Figure 2).

Figure 2. *Preschool group sample of this research*

The development of the activity was videotaped for analysis; this was done with two cameras, one fixed, and one in movement that allowed being closest to the particular activities performed by the children. The event was coordinated directly by the teacher of the group (and author of this paper), while the analysis of the videos was conducted in conjunction with the research team. In the next section we will explain in detail what was found in every step of the inquiry cycle.

Inquiry Cycle Implementation

Starting from the inquiry cycle shown in Figure 1, the first step involves "Building on the known (prior knowledge)". For this purpose as initial activity the teacher was showing small objects to the kids, before showing the object she would tell a small description of the subject and then asked the children "to guess" what object it was. These objects were things like a blender, a lamp, a laptop, cell phone, etc., when they were shown the teacher tried to turn them on but she was "unsuccessful", then she asked them what they thought the reason was, which spontaneously the kids responded that it was because "they were not connected" or that "they had no battery". This activity enabled a first connection with the ideas of the young students in the way that the objects of their common life had a need for "electricity" to proper operation. The next step at the end of the sample of objects was that the teacher will ask to the kids: "What do the objects that we just saw have in common? ".

It is important the role of guidance and more questions in every young child, in our case suggested by Traven (1998) the questions were appropriate and achieved more significant accomplishment in the children. Given the context of the activity, it was more significant that the kids will bind at objects displayed with the need of electricity to function.

The following statement was aimed at strengthening this first intention to build on the knowledge of the kids and to use different representations, in this case in its diary of inquiry the kid is asked to draw one or more objects they know that use electricity to operate, they had to comment on the drawings with both peers and the teacher. This activity was given a period of approximately 10 minutes.

In the next activity and returning to Traven, the children are asked, "where does the electricity come from?" Then, "what would you like to know about electricity?" With this couple of questions, furthermore answers about previous ideas of the children were obtained (Ramírez, Nieto, Ruíz, 2014). In this part we will work with abstract conceptualization of the kids from its concrete experience.

In the following activity, gives way to experimentation, in a first stage demonstration and in a next active step. Small balloon and carbon graphite (pencil shavings) are shown to the kids, and the teacher asks, "What will happen if the pencil gets closer?" This method resembles the Interactive Demonstration Classes and Cycle PODS (Predict, Observe, Demonstrate, synthesize) formulated by Sokoloff and other authors, and is very popular in the area of physical education (Sokoloff and Thorton, 2004, Ramirez and Chávez, 2012). Children make their predictions in their diary of inquiry; these can be written or drawn, and they have five minutes for a group discussion.

The teacher shows them the experiment and again asked them to register what was observed in the diary of inquiry. The teacher now proposes to "rub" the balloon on their hair and bring the balloon back to graphite and asked the question again: "What would happen if it gets closer?" The process of the registration of the prediction (hypothesis) is repeated, the observation and the results.

Closed this demonstrative part, the kids seem excited and this attitude leads to an active experimentation, where the little students undertake a personal exploration with the material provided by the teacher, a "kit" with a balloon, confetti, plastic ruler, and graphite, so that the little ones can experience what is going through the attraction of materials when charging the globe. Children are free to experiment with the material, and the teacher acts as a facilitator and only answers questions that the kids made.

Upon the completion of this step, the teacher returns to the abstract conceptualization. The teacher explains to the children that there is a property called electric charge and attract the balloons after rubbing materials due to the exchange of these electrical charges. It's important to remark that part again of what children already know, in previous stages of training camp and Knowledge World Exploration the little ones had learned about properties of matter as "smooth and soft" and acquired language is used to introduce the new concept in terms of the same language. At this point, the children ask questions about the topics covered, using the new introduced terms such as: electricity, charge, attraction, rubbing; fact that allows to anticipate the science standards required by the SEP are being developed. The generated questions will be detailed in the next section.

Finally, this had a closure of the inquiry cycle where the kids are questioned on what they learned in the session, the children answered that they added new words to their vocabulary (load, attraction, electricity, rubbing), compared with what was said at the beginning of the activity, they manifested a pleasure for the experimental activity and they actually asked the teacher if she can do more of this exercises and to continue using at home the "kit" provided. At the closure, the teacher congratulates the kids for being inquisitive, thoughtful, and balanced (all characteristics of the IB as discussed in the previous section).

The session lasted a total of 50 minutes, as planned in the inquiry cycle. As mentioned, the session was video recorded with two cameras; the video analysis of the next section is presented on the next section.

Data Analysis

From the inquiry cycle designed and the implemented activities directly on a classroom, one of the first concerns of the research group was to be aware of the preconceptions that the kids had about basic physics topics such as electricity, and from there to build a first elementary electric charge concept. The inquiry cycle in various stages of this research allows previous ideas, especially based on the guiding questions, as mentioned in the previous section (Ramírez, Nieto, Ruíz, 2014).

> *On first place, the little kids manage to identify a common denominator to show the teacher the objects and ask, "what they have in common?" Children build a semantic field in which electricity identify as the common factor between the displayed objects, which leads to the teacher to develop a new guiding question that connects to this new term to the concrete experience of the kids: "What other objects use electricity?", answers to this question are varied, however, it is clear that the children can clearly identify their everyday environment devices like television, cell phone, or computer, with the need to use electricity to function. An important situation is the changing of the term commonly used (at least in Mexico) as "light" to identify the electric energy. Another interesting point to note is that the kids already use the concept of semantic field, and in fact, had already used it in other areas of the Exploration and Knowledge of the World training camp, so the identification of electricity as the common factor between different objects fared easier and identifying other devices that use it for operation. There should not be forgotten that the SEP requests that preschool acquisition of a basic vocabulary is sought to advance the construction of a scientific language, Development of a greater capacity to interpret and represent phenomena and natural processes and the Growing Linking of the scientific knowledge with other disciplines to explain natural phenomena and processes, and their application in different contexts and situations of social and environmental relevance; something that stars to develop at this stage of the inquiry cycle.*

Previous ideas

So far in this cycle, children have shown their previous ideas in two formats or representations, verbally in a group discussion and graphically from drawings which expressed the objects they know that use electricity to correctly operate.

So far we have tried to make a connection between the term electricity and the concrete experience of the children, the next step of the cycle is now seeking a first generation of hypotheses through the guiding question "Where does the electricity come from?" For this question a variety of interesting answers were collected, considering exiting the concrete experience of the kids, unlike the previous guiding question. Some of the most typical responses were:

- Comes from the light
- Comes on pipes
- Comes from the United States of America
- Comes from the sea
- Comes in cables
- Comes with the sockets

Child's questions

It is interesting to see how it can be divided broadly into two kinds of responses, the first where the kids relate the origin of electricity to their immediate environment and their concrete experience, as is the case of cables, pipes, or sockets. In the second type of answers, children relate the origin of electricity with terms they are flashy and associated either by the media (television, internet etc.) or the social environment (parents, relatives, teachers), this is the case of answers like the sea, light or particularly the US, response that we would not expected to be present in children from other regions of the world or the United States itself. Before turning to the abstract conceptualization and active experimentation and searching, strengthen inquirers, thinkers and reflective features (promoted in the IB as mentioned above) and as part of the development of the Science Associated Abilities and Attitudes (two of the science standards proposed in the PEP 2011), we asked the kids to mention "What would you like to know about electricity?", the responses can be considered within the previous ideas of children as they are linked to the answers of previous guiding questions. Some of the questions for the kids were:

- How is a plug made?
- Can we live without electricity?
- Does the electricity come from countries?
- What if we touch it?
- How are the cables connected?

Moreover, moving from the stage of experimentation, as discussed in the previous section we proceeded similarly to a CDI way, so we showed the group the balloon and graphite pencil, and asked "what if the balloon is closer?"; in this case, three types of hypotheses are given by children:

- The balloon will "strike out".
- It "sticks" to the graphite.
- Nothing happens.

It's important to remark that the kids, like the term "semantic field", already knew the term "hypothesis" to represent their idea about what they think will happen in a situation.

After a small group discussion, the teacher makes the demonstration by bringing closer the balloon to the graphite. As a CDI, the kids used his diary of inquiry as a "sheet prediction" and "score sheet" responding graphically (with a picture) the questions "What do you think will happen?", "what do you see?", and "what happened?"

Immediately after the teacher "rubs" the balloon on her hair and again asks the group "what would happen now if I approach the balloon?" This time the answers were of two types:

- It is just like if it was not rubbed.
- It sticks.

Again, children make the registration of the three stages of the experiment in their diary of inquiry. As a next step in the cycle of inquiry, the children make active experimentation to be the ones handling the materials provided in the "kit" for the teacher, writing their observations in the diary of inquiry. These activities correspond to the abstract conceptualization to introduce a first definition of electric charge and its relation to electricity and closing the session where a recount of the learning is made.

Closing cycle

In this recount, the teacher asked, “What we learn today? “. The kids express their "new learning" using terms like electric charge, energy and electricity, they talking about the attraction or repulsion using like example the experience with the balloons and graphite, even more, the majority ask if they can take to home the "kit" to will show to their parents and that they can learn about electricity too. The kids are enthusiastic and solicited to the teacher to make more experience like that. On the other hand, the teacher was surprised by the answer of the group to want learn more about science, the child not ever looking for share with their parents the experience made in class and in this cases they were very interested in take to home their kit to show it to their family.

With this activity is closed the session after 50 minutes. Is notorious that after of this time (was surprising to researchers the exactness in the time) the attention of the group decreased significantly, so given by finish the experience.

The teacher evaluation rubric (appendix 1) to know the level of learning reached in terms of the standards of SEP. The rubric considerate three Achievement levels: Prentice, Rookie, Expert and Master; and evaluate three criteria: Knowledge, Made questions and Applied of knowledge in different contexts. With the results of the rubric is possible to determinate if the standards were reached and their level.

Conclusion

The objective of the introduction of some physical concepts in preschool class was reach out standards in science solicited in Mexico by SEP. In this proposal we use the physics like a means and not how end, with the finality of aid to formative field of the Exploration and Knowledge of the World. The introduction of new terms related to science and technology and to relate concrete experience that the children have, as well as allowing science, particularly in this case the physics, serves as a means to assist in the formation of the kids to encourage the acquisition of a basic vocabulary to advance the construction of a scientific language, developing greater capacity to interpret and represent phenomena and natural processes and increasing linkage of scientific knowledge with other disciplines to explain natural phenomena and processes and their application in different contexts and situations of social and environmental relevance, abilities that are proposed to be developed on the PEP 2011 to meet the standards of science in the preschool level.

On the other hand, it is clear that children can make valid hypothesis based on their own experience to assume that the demonstrative experiment of the balloon can "strike out" when closer to the graphite, or to assume that nothing happens. It is curious that children do not automatically take ownership of the explanation of the teacher and they would personally check with the "kit" which in effect graphite or confetti is attracted to the balloon after rubbing with their hair, so that could change or reinforce the prior idea. The previous ideas of the children are more complex than expected and therefore it is very important to use them during concept construction and activity design. They also shows that, when taken into account they help to the reinforcement of positive attitudes toward science, they encourage the development of certain attitudes like inquiry, open mindedness and rumination. Mindsets that, more benefiting the individual formative area, they are very important in the overall growing of our children. Since the results exposed from the implementation and evaluation of the a inquiry cycle based on a physics theme develop in the preschool students, the acquisition of a basic vocabulary to advance on the construction of a scientific language, the developing of a greater capacity to interpret and represent natural phenomena and processes and the increasing linkage of scientific knowledge with other disciplines to explain natural phenomena and processes and their application in different contexts and situations of social and environmental relevance. As result of this is possible affirm that in this study case did achieved successfully, Scientific knowledge, Application to the Scientific Knowledge and Technology, Science Associated Abilities and Science Associated attitudes, all this in the expert level at less in majority of kids.

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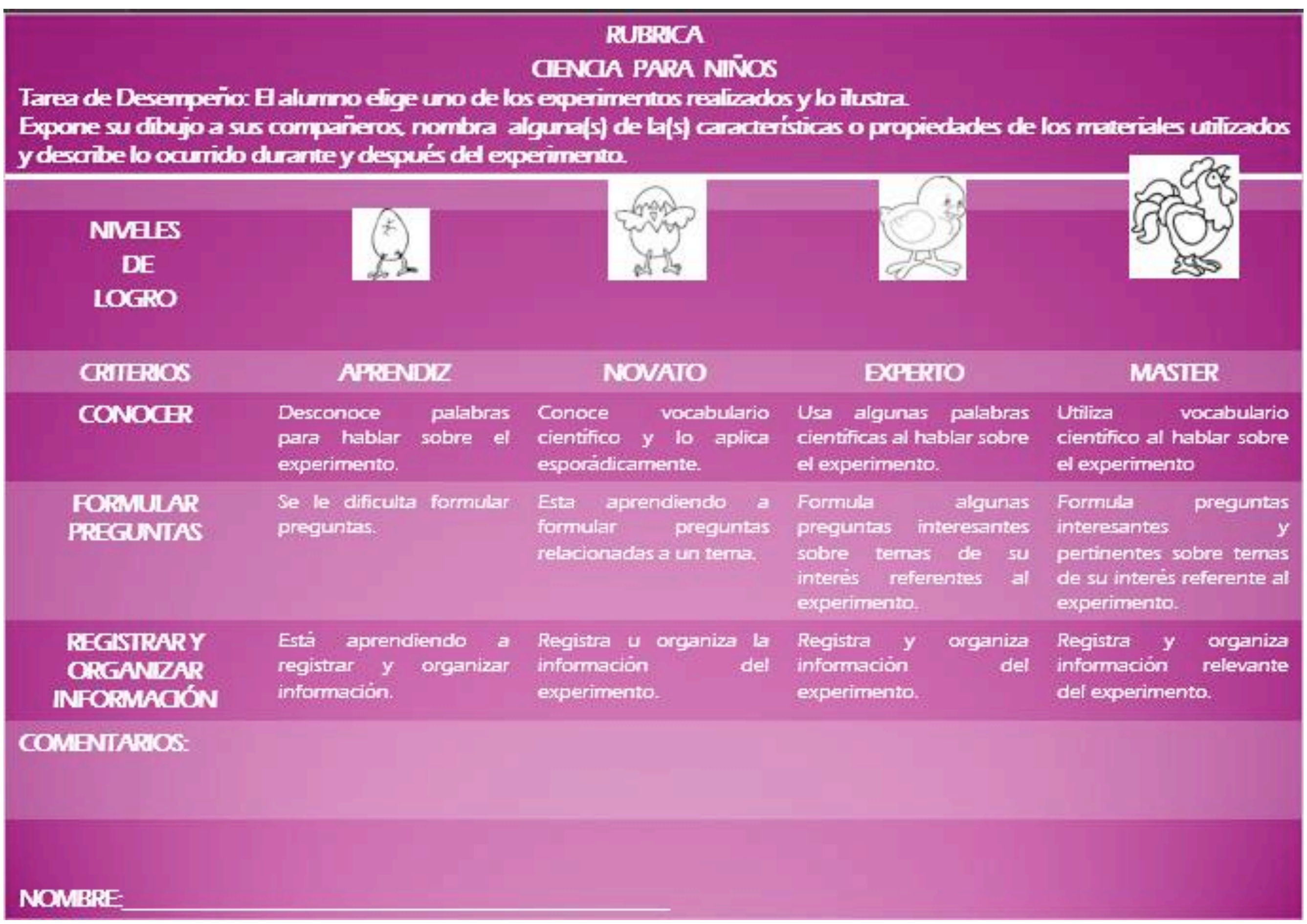
Appendix 1

Original rubric used to evaluate the kids achievement (Spanish language).



RUBRICA
CIENCIA PARA NIÑOS
Tarea de Desempeño: El alumno elige uno de los experimentos realizados y lo ilustra.
Expone su dibujo a sus compañeros, nombra alguna(s) de la(s) características o propiedades de los materiales utilizados y describe lo ocurrido durante y después del experimento.

NIVELES DE LOGRO				
CRITERIOS	APRENDIZ	NOVATO	EXPERTO	MASTER
CONOCER	Desconoce palabras para hablar sobre el experimento.	Conoce vocabulario científico y lo aplica esporádicamente.	Usa algunas palabras científicas al hablar sobre el experimento.	Utiliza vocabulario científico al hablar sobre el experimento
FORMULAR PREGUNTAS	Se le dificulta formular preguntas.	Esta aprendiendo a formular preguntas relacionadas a un tema.	Formula algunas preguntas interesantes sobre temas de su interés referentes al experimento.	Formula preguntas interesantes y pertinentes sobre temas de su interés referente al experimento.
REGISTRAR Y ORGANIZAR INFORMACIÓN	Está aprendiendo a registrar y organizar información.	Registra u organiza la información del experimento.	Registra y organiza información del experimento.	Registra y organiza información relevante del experimento.

COMENTARIOS:

NOMBRE:______________________________