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The effect of adult intervention in the development of science process skills

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Resumen

En el ámbito de la educación infantil se trabaja poca ciencia, y esto puede atribuirse a varias razones: a la falta de seguridad del profesorado, a una visión distorsionada de la ciencia como algo complejo y cerrado, y a la visión de que excede las capacidades y desarrollo psicoevolutivo del niño. Sin embargo, cada vez más estudios muestran que niños y niñas son capaces de participar en procesos de indagación y desarrollar algunas destrezas científicas. El papel del adulto resulta fundamental en este proceso de construcción. Por eso, la presente propuesta investiga el impacto de diferentes estilos de intervención docente en el aprendizaje.

Se presentan dos propuestas, una basada en las hormigas, otra en el magnetismo, ambas diseñadas para trabajar diferentes destrezas. En cada una se evalúa el desarrollo de destrezas científicas básicas y adquisición de conocimientos bajo una intervención guiada, directiva o libre. La intervención guiada mediante preguntas productivas es la que mejor resultados da en cuanto a la adquisición de SPS.

Palabras clave: ciencia, educación infantil, destrezas científicas, insectos, imanes.

Abstract

In the field of early childhood education, little science is worked, and this can be attributed to several reasons: the lack of security of teachers, a distorted vision of science as something complex and closed, and the vision that it exceeds the capacities psycho-evolutionary development of the child. However, more and more studies show that boys and girls are able to participate in inquiry processes and develop some scientific skills. The role of the adult is fundamental in this construction process. Therefore, this proposal investigates the impact of different styles of teaching intervention on learning.

Two proposals are presented, one based on ants, the other on magnetism, both designed to work on different skills. In each one, the development of basic scientific skills and the acquisition of knowledge are evaluated under a guided, directive or free intervention. The intervention guided by productive questions is the one that gives the best results in terms of the acquisition of SPS.

Keywords: science, early childhood education, scientific skills, insects, magnets.

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1. A NEW VISION OF TEACHING SCIENCE

1.1. Scientific reasoning in early childhood

Most studies on science education start from the primary stage, assuming that children under that age are not ‘’prepared’’ for understanding certain scientific phenomena. This is a very erroneous idea, because as it has already been shown in many recent studies (Koliopoulos et al., 2004; Robbins, 2005); 6 year old children are able to think scientifically using deductive reasoning and hypothesis, demonstrating at least incipient command of the skills of a scientist (Canedo-Ibarra et al., 2010).

Obviously, the stage of development of young learners does not allow for a complete growth of these skills at early ages; on the contrary, these abilities must be improved, and for that children must be provided with opportunities and contexts to do so. For doing that, it is seen that there are four processes of knowledge from which most learning theories derive (Sutton- Smith, 1970):

- Imitation becomes an imitative game, which makes the child have a great capacity for confidence in what is done.
- Exploration becomes an exploratory game in which the child discovers the connection between the things, places or people in the outside world.
- Prediction, testing, the child wants to validate the relationship that is having with the world.
- Construction, what would be the construction of the world, the child puts different pieces together and when he fits them, it gives a new meaning and a development of a higher level of operation.

In that way, intellectual development comes from the complex relationships that exist between different components, such as the perception of the different uses of one object and the manipulative and interactive experience that a person already has. In that way, continuous interactions are essential for the emergence of new cognitive patterns (Marayuma et al., 2014).

One of the first who recognized the great importance of movement in the development of the mind was Piaget. Likewise, the *Dynamical Systems theory* states that the interaction with the environment is fundamental, since it is linked to sensory–motor activity. So, it is proved that ‘’by continuously perceiving and acting in our environment, we are dynamically updating the current state of our cognitive system’’ (Marayuma et al., 2014, p. 398). So, it can be said that the best way of teaching children is to provide the basis for fruitful exploration.

Besides direct experience, according to Piaget’s work, the formation of concepts is due, in large part, to language. Indeed, interaction with others through speaking and listening is a good way of developing children's ideas (Harlen, 2018). Children's talk can play a fundamental role in the development of understanding when it becomes a dialogical form of talking. In other words, think aloud about something.

Furthermore, it is important to bear in mind that the child is the one who actively seeks and provokes stimuli. In others words, children ‘’are able to negotiate the trade-off between exploration and instruction such that they explore more when they can rationally infer that there is more information to be learned.’’ (Bonawitz et al., 2010;p.8).

Unfortunately, in many schools this respect does not exist and it is drawn towards a standard model of traditional curriculum to which the student must adapt, and which does not prepare the children for their future. This could make the children lose the natural curiosity that exists from a very young age (Fine & Desmond, 2015), which in the long term results in disengagement with the process of learning, non-meaningful learning and, eventually, in school dropout.

As Siayah et al. (2019) defends in their work, scientific concepts are the basis for solving problems in the outside world, for studying nature itself, appreciating it, removing misconceptions and fears from one's head. So in that way, science and scientific activity goes beyond productive activity, and must be understood as a tool for understanding the way the world works, with joy and pleasure.

For all these reasons it is needed to teach science as a tool for interpreting the children´s world, within their reach. Exploring phenomena that can be directly verified not only helps satiate children’s inborn sense of wonder, but is also a path for maturity and cognitive development (Fine & Desmond, 2015; Harlen, 2007).

1.2. Scientific process skills

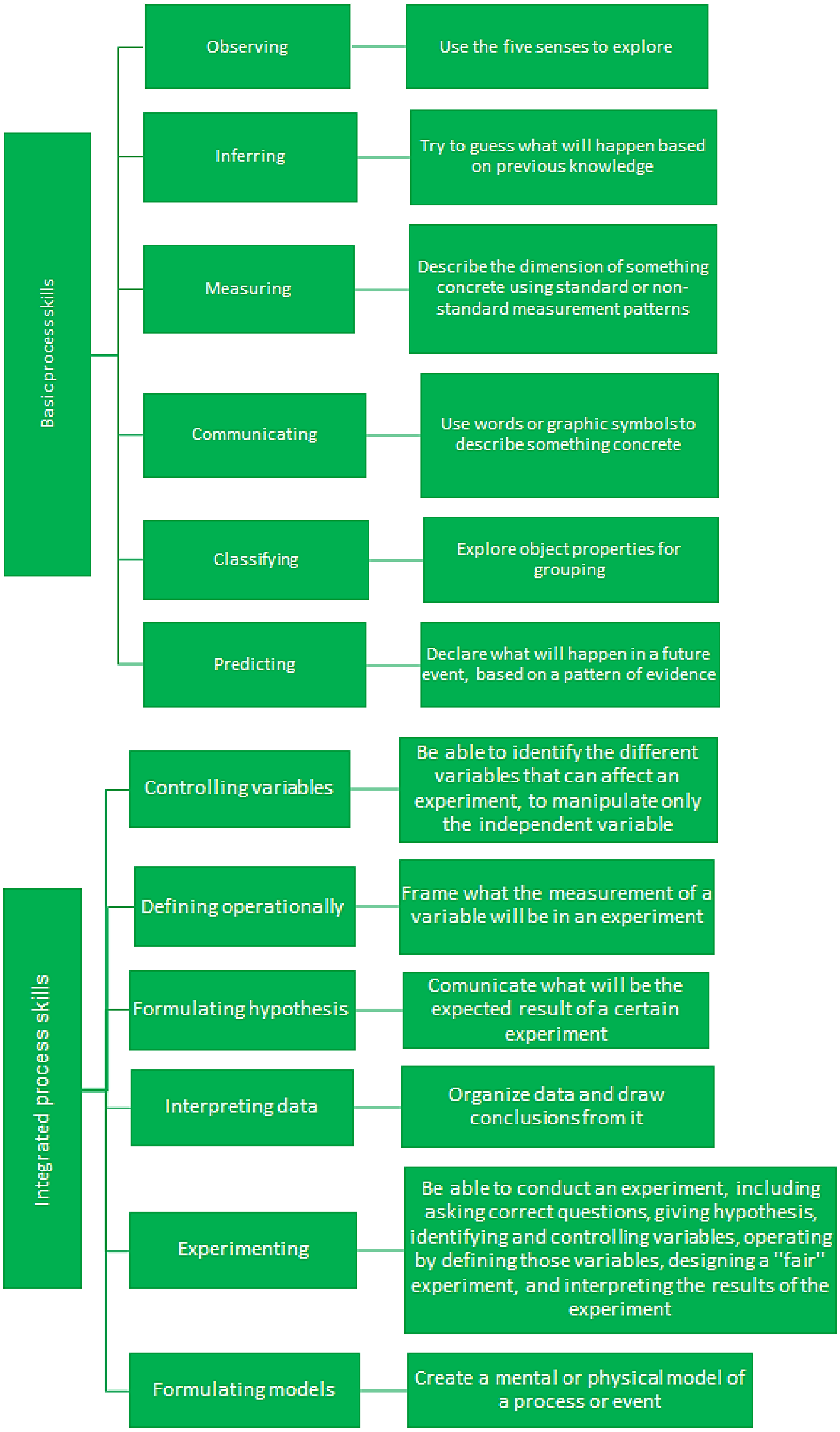
If school science is useful to interpret the world, learning does not end with formal education, it continues throughout life, which needs to address the children’s desire to know and must face them with decisions based on data. For that, the way of teaching is required to have certain skills and an exposition of them to situations in which science is done. These skills can be acquired in the educational process and that is why it is very important that the level of these skills go up as high as possible (Harlen. 1999).

Science teaching has evolved from teaching concepts towards teaching skills (Mirana, 2019), as it becomes evident from the increasing demand for projects such as Fibonacci, a European project that wants to foster and disseminate inquiry - based science education.

Talking about science, involves unique process skills, which can be defined as “a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behaviour of scientists” (Padilla, 1990), and which include actions such as critical thinking, hypothesizing, manipulating and reasoning skills. The basic (simpler) process skills provide a foundation for learning the integrated (more complex) skills (see Figure 1).

Figura 1.

Process skills



Note: Adapted from *SAPA*

The development of SPS depends on the maturation of the child, which may constrain or limit the development of more complex processes. Some authors recommend that only the basic science skills are taught to young children (DeBoer, 2000), but some others, such as Ergül et al., (2011) suggest that child develop thinking using the different science procedures available, as it can provide a solid base for future studies and what is more important, it can be used to solve problems in their future life.

SPS are inseparable in practice from the conceptual understanding that is involved in learning and applying science (Harlen & Gardner, 2010). In conclusion, the learning of SPS should never be neglected with excuses such as lack of time or overloaded programs. ''A student who does not have the basic skills could not improve the skills about performing experiments easily'' (Ergül et al., 2011, p.63).

Also, it has been shown that SPS can be learned; when process skills are explicitly targeted in specific science programs (Padilla, 1990). Therefore, the most important point is to improve the range of skills available, to be able to solve the problems of daily life (Kane et al., 2016). The issue is that as the use of SPS in school is increasing, certain tests to evaluate them, such as the OECD PISA, are being given. The problem comes when SPS have to be evaluated depending on certain contents, instead of doing a review depending on what teachers want to achieve with this evaluation. For all this, it is crucial to raise awareness of creating an evaluation of these skills coherently. That appraisal must be done with extended tasks and based on what teachers observe in their daily work (Harlen, 1999).

2. CREATING LITTLES SCIENTISTS

2.1. Rethinking science education

Nowadays, the educational systems are complex structures in which the politicians determine curricula (Rahm, 2014), something that does not favour education. Those systems have noticeable drawbacks: as shown by Torres Valois et al. (2013), high school and undergraduate students use less scientific concepts than expected when describing, explaining or predicting the operation of certain devices through causal relationships and what is worse they even hold totally erroneous ideas from a scientific point of view, even animistic ideas. This is scarcely alluding to the basic scientific principles and laws that serve to explain the devices and also, a lack of training in scientific skills.

All of this triggers a great alarm signal among teaching professionals and forces teachers to think about the methods that have been used and their effectiveness. These methods place little emphasis on the alternative ideas of the students and it is seen that the conceptual errors are not corrected over the years (Torres Valois et al., 2013). That means that the science being taught is not functional and cannot be transferred to the real world, which raises concern that it is necessary to use more authentic scientific practices that develop scientific SPS.

As seen above, science experiences in the classroom should allow students to make sense of phenomena in everyday contexts, and endow them with thinking abilities (SPS) that can be transferred to multiple areas of activity. For that to happen, children must be active, involved in their learning and assistants in co-construct knowledge from something that generates interest and meaning for them (Fine & Desmond, 2015).

In this vein, the first element that needs revision is the contents, to ascertain whether they are adequate to the life reality of students and central to the understanding of science. The selection of ten ideas of science and four about science of Harlen (2018) may be useful in designing this progressive process through the school years:

Of science:

- All materials are made of very small particles.
- Some objects can affect other objects at a distance.
- Changing the movement of an object requires a force to be acting on it.
- The total energy in the universe is always the same but it can be transferred from one energy to another during an event.
- The composition of the earth and its atmosphere and the processes that occur in it, shape its surface and its climate.
- The solar system is a very small part of the billions of galaxies that exist in the universe.
- Organisms are organized on cellular basis and have infinite life spans.
- Organisms require a source of energy and materials that they often depend on or compete with other organisms.
- Genetic information is passed from generation to generation from one organism to another.
- The diversity of organisms, which live or have become extinct, is the result of evolution.

About Science:

- Science serves to find the cause of phenomena in the natural world.
- Scientific explanations, theories and models are those that best agree with the factors that are known in a given time.

- The knowledge produced by science is used in engineering and technology to create products for human purposes.
- The application of science sometimes has social, ethical, economic and political implications.

2.2. Transforming the practice

Changing the way science is taught for making it more effective involves more than changing the content being taught. How to teach in a science classroom is complex, starting from the notion that the methodology used will determine the perception of science that the students have. According to the study by Granja (2015) humans build their learning and give it a meaning depending on the experiences they have had. These ideas are in line with Piaget's theory of adaptation, which includes assimilation and accommodation. As he said, the subject learns actively and gradually.

According to this author, the main goal that education should have is to raise people who are capable of doing new things, creative and not simply repeat what has already been done. In other words, teachers have to be capable of knowing how to move learners to do new things, while at the same time, teach what others have already done. For all the above, for good learning, the scientific method must be applied, without forgiving to involve the students in the research processes.

Sometimes it is believed that free play is somewhat self-taught, and undoubtedly it provides a variety of opportunities of learning (sensu Pikler). However, the intervention of the adult can be pivotal in moving children from their actual development zone to the proximal development zone (*sensu* Vygostki), overcoming the limitations of discovery learning.

This intervention may include a range of actions, from providing adequate environments that facilitate the development of their experiences (Santer et al., 2007), to guide exploration with timely clues. The function of these clues should be to engage the children in exploration, so as to increase the time they spend focusing their attention on the task that is being done. In that way, from a young age, students are taught to regulate their attention and the success rate at higher levels will be higher (Gardner-Neblett et al., 2016).

In sum, teachers must change the dynamics towards a process of inquiry, which may require making minor changes in the materials, spaces and language/communication.

2.2.1. Adequate materials and proposals

Having a good criteria to choose the materials they are going to be used is essential, a right idea is to supply instruments for observing, measuring… According to Pedreira & Márquez (2017) there are five elements to bear in mind, (see Table 1).

Table 1.

Criteria for the election of materials.

CRITERIA	EXPLANATION
Prefer natural	Offer more opportunities for exploration with richer stimuli.
Safe	Allow to forget about safety and focus on the task.
Open ended	Foster creativity, more engaging.
Science rigorous	Fragments of reality that serves to illustrate the scientific idea.
Local	Can be encountered in everyday life.

For all, it is needed that for having a good exploration, there have to be environments that enable students to develop SPS (Turiman et al., 2012). For example, to nurture exploration – one of the most basic and most used basic skills is observation, where students use their senses to gather information in their surroundings (Monhardt & Monhardt, 2006) - teachers should choose a good work environment for children to explore productively and freely (Santer et al., 2007). To conclude, there are some indications to make better proposals, for instance:

1. Do not give written instruction to children under 6 years, in some cases, they are not able to read and understand the message. But it is a good idea to give them some grammatical templates, which will help them to structure learning.
2. Design self-evident proposals to foster autonomy and avoid written instructions.
3. Use surprise to create curiosity and engagement.
4. The temporal distribution of the sessions is essential to give continuity and build coherent integrated projects (D.E.T, 2012).

2.2.2. The importance of language

In the field of science, language and communication are basic for learning since, depending on how the questions are formulated and when the teacher intervene, their effect can vary greatly, from promotion to inhibition of exploratory learning (Harlen, 2018).

Use of language

According to Harlen (2018), the big point is that talking about science means doing science using language. For this, practicing science increases the use of descriptive language as it encourages the comparison, observation and contrast of certain characteristics or events.

In that way, students have to be able to listen and respond in a formal and effective way. On one hand, when a teacher starts a lesson it is necessary to have a discussion in which the whole class participates to motivate and hook them. On the other hand, at the end, this discussion will serve to think about what has been learned and the different implications that it has.

For that, a good way to do it is seeing talking as thinking aloud, which gives the opportunity to reflect and communicate through dialogic talk between peers. As it is shown in Harlen (2018) the self-talk that children can have on some occasions has an important role in developing their understanding, since this form of dialogical speech consists of thinking aloud about a certain situation. In that way, dialogic talk provokes thinking in which there is an interchange with the aim of exploring in depth an event. Also social interaction in a given learning environment can help students to construct new representations that they do not have yet (Canedo-Ibarra et al., 2010).

Harlen (2018) states, there are some points that are important and can help with the dialogic talk, for instance:

- Use children's ideas for explanations.
- Ask for clarification.
- Encourage children to respond to others, not just keep what they think.
- Promote active listening.
- Set expectations that children can meet, that will be hooked on and they will strive to achieve it.

Another point to bear in mind is the creation of good schemes. For that, introducing new words is important for a better understanding. It is true that teachers have to be aware about the type of vocabulary that they teach to students because it is important that it starts from concrete things (the ones they can touch, they are in their daily life) and then teach more abstract concepts when the years pass (Elstgeest, 1985).

It is true that technical vocabulary helps students to be more precise, and to better understand the meaning, since the same language is shared, but, being careful since there are also certain contradictory words at first that can kill the interest. For all this, before introducing scientific words, a series of questions must be asked, such as: is the word important?, Will it help the student to understand in a better way?, Does the student have experience?… (Harlen, 2013). If the answers to these questions are yes, then it is the right time to introduce them (Harlen, 2018).

Also it is important to know how to introduce these words; one of the best options is by using the new word repeatedly in different contents, using the new word repeatedly in different contexts. Another way that teachers can use is by completing the reasoning that children have, through that word, refining their answer and taking into account what they have previously told (Harlen, 2013).

Finally, a big issue is the diversity of the classroom. Teachers must always take into account that children can have difficulties in their speech and therefore it will be necessary to scaffold them. In that way, as Harlen says, they will be able to gain confidence in the use of scientific words.

Questions

The use of good questions in the suitable moments is very important since asking a poorly formulated question is anti-productive for the learning of students. The main object of question should be to encourage children's activity and reasoning (Elstgeest, 1985).

Asking a good question, is the first step towards a good answer because that question invites the students to continue exploring where the answer can be found. A good teacher does not ask them to say something; it asks them to demonstrate anything that makes the students being active with his question. As Fine and Desmond (2015) states, the questions have to be open-ended as well as to follow the learning objectives they have, but they must also be capable of directing the child's thinking.

Different types of questions can have different effects on children (see Table 2). Teachers should know students and be capable of distinguishing if the kinds of questions they do are productive or not. For teachers, these questions can be used as an indicator of problems that students have in their learning, and can give information about what students are thinking (Chin & Osborne, 2008). In that way, it is a good idea to study the effect of the question on children (Martens, 1999).

Table 2.

Categories of productive questions.

TYPE OF QUESTION	USE	EXAMPLE
Attention-focusing	-Start fixing attention in the most significant details that they might overlook to reach more complex questions. -Simplest form of a productive question.	-Have you seen…? -Do you notice..?
Measuring/Counting	-Check their answers themselves using new skills, instruments... What leads to comparison questions. -Qualitative towards quantitative observation, help them to become more precise in their observation.	-How long..? -How many? -How often?
Comparison	-Sharper observation having in mind that things can be different in many characteristics, help them to fix attention in the important points required. -Analyse and classify.	-…how do they differ in..?
Action	-At the beginning of a scientific study which are the characteristics of the new materials. -To encourage experimentation that can be always genuinely answered, with great value and form a relationship between his exploration and the reaction of the material. - It is the first step to predict which is the ability that sets up the basis for problem-solving.	-What happens if..?
Problem posing	-Set up a real problem situation in which children give an answer, the real prediction question in which children begin to make a real progression.	-Can you find a way to...?
Reasoning	-Reasoning questions make them with caution as they are very important for a given explanation. -They make children think, reflect and reason, based on their experiences. -Break up big questions concepts in small ones.	-What for..? -Why do you think..?

Note. Adapted from Productive questions: Tools for supporting constructivist Learning, Martens, 1999.

2.2.3. The role of the adult

The adult has an essential role as director in the exploration game, which is why, depending on the type of training that the teacher has, the intervention will be in one way or another. It is therefore, intervention is essential since it can be given in various ways and the role it takes will make the quality of education different, so in that way it is essential to be well trained.

According to Pedaste et al. (2015) it is important to know that in a structured learning environment there are two options: Give all the information, guide the actions and the information on the expected responses of the learners in each phase in which the framework can be applied for the design of the main structure of the learning space, or leave more freedom to those who learn when they are guided towards a productive learning based on specific topics that have been detected during the learning process. In this last case, it is important to take into account the needs of the learners since they must have the main supporting elements of a learning space.

That is why it is important to carefully design the scaffold that is provided, including degree of intervention, timing and format as depending on when the instruction is given, the student has the possibility to investigate more or less (Bonawitz et al., 2010). For this reason, the way in which teachers guide those first exploration experiences is so important, since depending on the information that educators share with their students, their knowledge will be increased, and the adaptation to the world that surrounds them will be more appropriate. Educators may not be aware of it, but they have the key to the best development. This productive teaching should lead children to generate powerful ideas related to a context, giving coherent arguments, through experiments (Granja, 2015).

In the learning of all these processes, the role of the teacher should be to enhance the learning processes, without determining or forcing them (Granja, 2015). For doing that based on the study of Bonawitz et al. (2010) teachers have to be very clear about having a balance between giving direct instructions and letting children explore. On one extreme, they have the demonstration; i.e., to show a phenomenon or, in the best case, to give the children direct instructions to do it. In most cases, children do not go further in their discovery, thus putting limits on their exploration, even if the teacher encourages them to do it.

It is also shown that preschool children extend their assumptions, in a rational way, to contexts in which they hear some instructions given to similar students. On the other extreme, there are children who explore autonomously all the possibilities that the given object has in that way as Vygotski states in the early years, students learn, above all, through exploration in an active way with their environment.

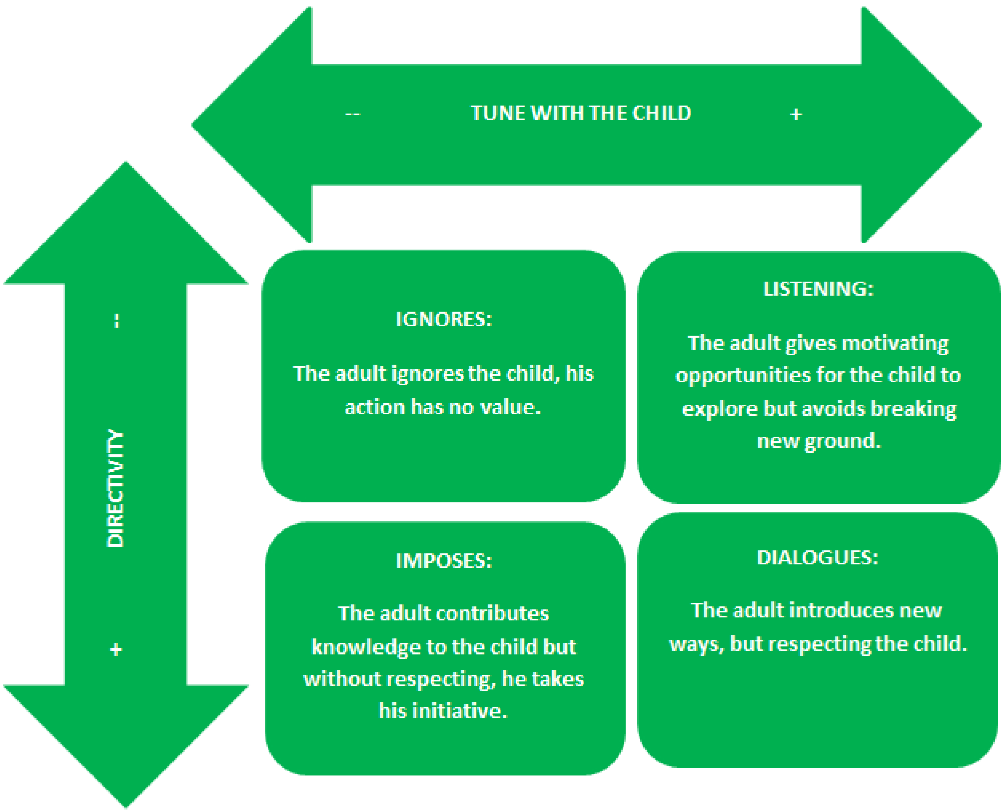
Adult intervention

One of the basic principles when intervening in the classroom is that teachers must be able to accompany children as they explore their questions without anticipating and without teaching them anything that they themselves can learn (Pedreira, 2018). As it is shown in Harlen (2007) chapter, the teacher is another member of the working group whose role is to help them in their learning, clarifying messages and encouraging them to continue their learning with their explanations.

According to Pedreira (2018) adult interventions can be based on the level of directivity (adult's choice to give new ideas or not to give) and also in tune with the child taking into account what he is doing. If interrelate these two dimensions, appear the different types of standard intervention reflected (see Figure 2).

Figure 2.

Types of intervention



Analysing Figure 2, it becomes obvious that the type of intervention appropriate for promoting an active response of the child (behaviour that increases dialogue with knowledge) is the intervention that listens and dialogues. According to Sanmartí (2010) cited by Pedreira (2018), this kind of intervention is more likely to provide the group with a degree of expert knowledge from asking questions that help to look at the situation from new points of view, rather than transmitting only information or abstract concepts.

Importance of teacher training

Teachers' level of training has been shown to have a profound effect on the outcomes of the learning- teaching process (Supovitz & Turner, 2000). Fortunately, teachers, who are willing to train, are most of the time eager to reformulate their classes and to improve, to obtain better results.

For all this, Supovitz and Turner (2000), identify 6 main elements that characterize a good quality of teaching:

- To know how to use the different programs that model scientific reasoning.
- Professional development must be intense and sustained over time.
- Professional development must be given at school with students and peers.
- Focuses on teachers' behaviours do not have as positive and lasting effects as those that focus on matter knowledge and on student learning, in a given subject.
- Importance of professional development, in common indicators to the rest of the colleagues.
- Importance of not separating the relationship between the staff and the school if we want to foster a good development.

In addition, it has been proven that the more a teacher knows about what they want to teach and the more information they have, it is more likely that the student discovery is broader with that teacher than with another.

To conclude, the teacher's knowledge can greatly contribute to opening up new horizons for the student, as regards education and learning (Elstgeest, 1985). Since, these teachers know how to measure and provide information with good quality, seeing what the point of interest is, and generating the necessary interest for them to start looking for an answer to their problem.

2.3. Learning through inquiry

According to the National Science Educational Standards (1996), the inquiry-based teaching method refers to a multifaceted process of gaining information from different levels of investigation. The standards compare the inquiry processes in the classroom with the activities and thought processes of scientists in real life. Inquiry in both fields requires that: all participants make observations, ask questions…, being active participants of the process and at the end share their findings. In other words, for the achievement of this level of maximum engagement, students must be always active in their own learning.

A more recent study realized by Fine & Desmond (2015), supports the idea above, it has been seen how teaching by inquiry invites children to be the centre of their own learning. In this methodology, when children have meaningful questions, they are encouraged to solve them by evaluating possible solutions, through experimentation. Teachers guide students to expand, analyse, and defend new hypotheses that emerge from applying the new learning in a constructive way. The results of this study have shown that learning was better and richer when teachers let students have initiative, ask their own questions within a group.

What is the main point of this method is that the results of different studies carried out, such as Ergül et al. (2011), show that the use of inquiry learning methods significantly increases skills and good attitudes towards science. In this study they suggest that teachers must first follow a program that makes students acquire SPS, which as it is shown above, is fundamental. Then, they must integrate that program with the science curriculum due to the hierarchical structure that the SPS have. In that way, starting in schools doing experiments is a big mistake since that is almost like starting from the end of the sequence.

Therefore, the teacher in this approach must act as a learning guide which facilitates the exploration of the issues and decides on the fly. This is because the teacher must actively listen and reflect on the thoughts that children have in order to provide them with materials and provocations, in a way that their learning expands (Fine & Desmond, 2015). Furthermore, it is important to help students to develop their conceptual understanding and at the same time to develop their skills for the inquiry and investigation processes (Harlen, 2013).

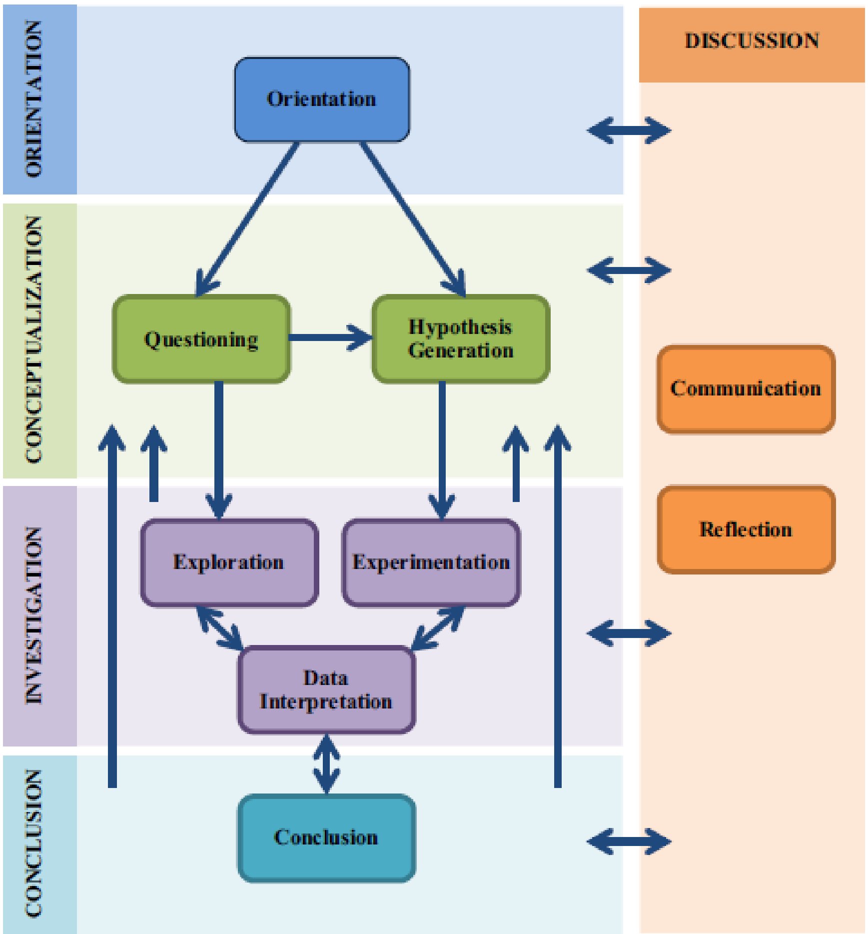
All of this has a framework which can be followed with different phases, according to Pedaste et al. (2015) the phases of this method can be organized differently depending on the specific learning situation (see Figure 3).

In addition, something that is very important in this process is documenting it through photos, videos...so that later, both the teachers and the learner, would be able to see all the work that they have carried out, the processes and what they have achieved (Fine & Desmond, 2015).

In summary, as Fine & Desmond (2015) state in their study, Inquiry- based science education empowers children to have their voice heard and at the same time they need to be critical about their own learning.

Figure 3.

Phases of inquiry



Note. Adapted from Inquiry-based learning framework, Pedaste et al., 2015.

2.3.1. Scientific method

Another aspect to consider in this inquiry process is the implementation of the scientific method in a good way. Although inquiry processes draw on the steps of the scientific method, following this method is not sufficient (Tang et al., 2010). Indeed, the method is usually taught in a rigid way and by heart, what may distract the teacher from what is important -the student's thinking- and leaves no space for scientific thinking. For this reason, taught in this way, the scientific method does not contribute to promoting inquiry learning, but rather suppresses it (Tang et al., 2010).

For clearing up, the difference between the inquiries teaching model and the traditional one (see Table 3).

Table 3.

Traditional vs. Inquiry teaching

TRADITIONAL TEACHING	INQUIRY TEACHING
Teacher explains the concepts with the help of demonstrations and hands-on verification activities.	Teacher engages and guides students through investigations, making observations and arriving at explanations.
Teacher's responsibility is to expound clearly.	Teachers' responsibility is to elicit, challenge and scaffold student thinking and encourage wider responses from the class.
Teacher engages students in questioning that does not lead to discussions; teacher goes through a sequence of questioning, accepting or correcting answers where necessary but rarely follows up with further probing.	Teacher consistently engages students in open-ended questions, often leading to discussion and debate where observations, assumptions and reasoning are challenged by the teacher or other students.
Students' utterances are often in response to teacher's questions and usually consist of single, detached words, many a times in chorus.	Students' utterances are not restricted to direct answers to teacher's questions, are expressed in whole phrases/ sentences and may be tentative.

Note. Adapted from *A summary of the characterisation and differentiation of inquiry teaching and traditional, direct instruction based on the literature and our own observations which applies to the two teaching modes in our study,* Kawalkar and Vijapurkar, 2011.

2.3.2. Teacher difficulties

According to Harlen (2013) & Couso (2014), something that is very common, is to see inquiry as a methodology of manipulative activities. This causes that the essential point of this methodology is lost as the use of evidence that can be found in direct action towards objects, can also be found in secondary sources, such as the internet.

To prevent that, what teachers always have to bear in mind is when explaining school science, what is important is the mental activity that students experience and not what happens in the experiment. For this reason, the crucial aspect of what science teaching contributes is precisely that way of understanding a certain phenomenon and the ways in which the teacher can help the student to build the way to understand it in school science (Couso, 2014).

Furthermore, teachers need to be prepared, as we have seen, to implement all the process of inquiry in a good way. Nevertheless, teachers can have some difficulties at the time of the lesson, for example in developing children's own ideas, designing hypotheses or helping them to interpret data and discuss. Also, they can have difficulties that appear constantly as for instance: being nervous of mixing up guided and open inquiry, not to understand in a fully way hypothesis and lack of training to understand science content (Yoon et al., 2012).

Additionally, it is important to bear in mind the attention to diversity in the class, people are all different and with different necessities, so they have different rhythms of learning. In that way, measuring the maturity of the student and the type and complexity of the activity it is a must. It is necessary to guarantee the equity of all students and science has to be given to a large audience. Everyone must be guaranteed and given opportunities to participate physically, cognitively and socially in science activities (Rahm, 2014).

To sum up, as has already been seen, it is a common mistake to think that students should discover everything for themselves and should not be given information by teachers or by other means. Since, if this were the case, students would develop their ideas through inductive thinking thanks to new experiences, their open mind and observation (discovery learning). On the contrary, this model from the constructivist perspective sees students as subjects who face new experiences with ideas formed with previous experiences (Harlen, 2013).

3. DIDACTIC PROPOSAL

Taking all of the above as a reference, it has been decided to develop a proposal to carry out in the classroom, where you can really see which is the best intervention method and what type of questions are those that favour SPS and scientific thinking. In addition, through this proposal we want to contribute to SGD # 4 Quality education for all. This objective of sustainable development aims to guarantee access to an inclusive and equitable education so the main aim, is to achieve a quality education. Therefore, what is wanted with this proposal fits very well with this goal since it is intended to promote the acquisition of knowledge and skills to fit adequately in society.

3.1. Objectives

General objectives:

- Describe the effect of a proposal intended to develop Science Process Skills on learning of science among young children.
- Describe the impact of adult intervention on the engagement with science tasks and their impact on learning.

Specific:

- Analyse the effect of different styles of adult intervention on the development of SPS.

- Design interventions that can be considered good practices, to facilitate that the different educational agents engage in scientific activity.

3.2. Design

The design of this project has an experimental character, since it seeks to verify the effects of a specific intervention; Qualitative and quantitative, due to the very nature of the data that is collected, exploratory - descriptive, since it approaches reality to collect the data and describe how they are; and transversal, since it will only be carried out in the current situation and moment and not in successive moments in time.

A socio-critical line of research will be followed, which, as Martínez González (2007) points out, has been very well accepted in the field of Education since it has been applied in different areas such as the development of the curriculum, improvement of school programs, teaching innovation, etc.

In other words, this proposal is based on the needs that a certain group has, in this case, infant children and their scientific learning. What is wanted with this proposal is to reflect on how to increase the presence and the effectiveness of science activities in the Early Childhood classroom. In this vein, one of the objectives of the research is to develop a guide of good practices to help teachers in science teaching.

3.3. Context and participants

A Public School in shout of Navarra.

The proposal will be made in Spanish, since despite the fact that the school is immersed in a program of learning English, the hours have been reduced to the minimum required per week (8 hours) and it is seen that infant children, many of them, have difficulties when it comes to understanding when they are spoken to in English and limitations to express themselves. For this reason, their responses could be conditioned by this lack of understanding/linking technical – everyday vocabulary - phenomena. In addition, another aspect to highlight is that in this school, in many of the classes more than half of the students are immigrants, so they also have difficulties in some cases, with expression in Spanish.

A positive aspect is that this school already uses Project Based Learning and thus they are already acquainted with some of the phases that are going to be seen in this work. For instance, when starting a project they always point out what they already know. Also, something good is that as I go through all the classrooms for doing my practices, I already know most of the children and they know me, which gives them more confidence when responding and interacting.

The participants included 42 children, aged 4 – 6, belonging to 3 classes (group A: 2nd course, n=14; group B: 2nd course, n=13; group C: 3rd course, n=15).

Regarding sampling, the type of sampling is for convenience, since, as indicated by Otzen and Manterola (2017), there was previous contact and the subjects were more accessible. To request collaboration, I spoke personally with the school exposing the proposal, receiving a positive response for collaboration.

3.4. Sequence of activities

There will be two distinct proposals, one based on magnetism (2nd course) and the observation of ants (3rd course). In spite of the themes being different, they share some features in common: they target specifically the development of process skills and also others that differentiating: while ants proposal focuses on observing, the magnetism proposal focused more on inferring and predicting.

Both of them include phenomena that are within reach and belong to the everyday context of children, and they serve as a context to attempt different degrees of adult intervention, which allow the identification of most productive alternatives (ver sección 3.5. Instruments of investigation).

The proposal of ants is going to be carried out in 5 year old class. It encompasses 8 sessions distributed from March 11 to April 29, since it is a proposal that needs time to see the evolution. However, the magnetism proposal that will be carried out in the two 4 year old classes consists only of 5 sessions held in the week of March 15 to 18.

Proposal 1: Ants

Location of the contents in the curriculum:

The proposal is based on the official curriculum of the second stage (3-6 years) of infant education (Decreto Foral 23/ 2007), in which it is established the curriculum for the second infant stage, described in the provincial decree (Navarra, Departmento de Educación 2007). Specifically, attention will be focused on the area of knowledge of the environment in two specific blocks, the first one related to the physical environment and the second one of approach to nature. In addition, a series of transversal contents will be taken into account, such us: Initiation in the use of technological instruments (see Annex 1).

General scheme of activities:

General description: draw ant and anthill, observe in class and in the garden, and reflect knowledge again (see Table 4).

Table 4.

General description of activities[1]

TITLE	PHASE	DESCRIPTION	SPS	DATE
1.What do we know about ants	Introduction	- Draw an ant - Start the project (KWL)	-Observe -Communicate	Day 1
2.Our anthill	Development	- Draw an anthill - Prepare our ant hill	-Observe -Communicate -Predict	Day 2
3.Taking care of our ant hill	Development	- Observe the changes that happened in the anthill	- Observe - Communicate -Measure -Infer - Interpret data	Day 3 and once a week
4. Let`s search for an anthill!	Investigation	- Look for anthills in the school yard - Observe ants paths - Draw what have been seen	- Observe -Infer -Communicate - Formulate hypothesis -Interpret data -Predict	Day 4
5. What do ants eat?	Investigation	- Find out what ants eat	- Observe - Communicate -Classify -Predict - Infer - Formulate hypothesis - Interpret data - Experiment	Day 5
6. What have we learned?	Conclusion	- Review what has been learned - Make a final drawing -Make conclusions	- Observe - Infer -Interpret data - Communicate - Measure	Last day
7. Show to our family what we have done	Conclusion	- Summarize and remember what has been learned showing to the families	- Interpret data - Communicate	At home

[1] The activities of this proposal are developed step by step to serve as a good practice (see Annex 2).

SPS that have been launched: especially basic. We also want direct knowledge of the beings in the environment. To measure adult intervention, groups underwent different "treatments" in sessions 3, 4, 5 and 6 (see Table 5).

Table 5.

Description of activities subjected to differential treatment

	IMPOSED	DIALOGUES	LISTENING
Act 3. Observe ants	Prompted to observe specific structures, using technical vocabulary. *Look, they take the food with the front part; they have clamps like a jaw...*	Guided with questions such as: *Have you seen? Have you figured? Have you noticed? How many? Why do you think?*	Given freedom to observe for a while then asked to tell what they have observed.
Act 4. How can we make ants deviate from their path?	Carry out the action of passing the hand without the previous action questions	Ask action questions to help them make predictions: *What will happen if you rub your hand on the path? And if you move the leaf?*	Probe question, only leaving them to be the ones that direct their exploration.
Act 5. What do ants eat?	Directing the exploration	Helping with questions to focus their attention/reason.	Freely leaving
Act 6. What have we learned?	Will be told things like: *Look, they take the food with the front part, they have clamps (is a jaw).*	Will be helped with questions such as: *Have you seen? Have you figured? Have you noticed? How many? Why do you think?*	Be asked to tell what they have observed.

Proposal 2: Magnetism

Location of the contents in the curriculum:

It is going to take as a basis, the blocks of the Navarra curriculum for the second infant stage, described in the provincial decree Navarra, Departamento de Educación(2007). Of these blocks, attention will be focused on the area of knowledge of the environment in one specific block, related to the physical environment. In addition a series of transversal contents will be taken into account such us: Use of the senses (see Annex 3).

General scheme of activities:

General description: see what is magnetic, observe the strength of magnets, the poles and reflect knowledge again (see Table 6). SPS that have been launched: especially basic. We also want direct knowledge of phenomenon of the environment. To measure adult intervention, groups underwent different "treatments" in sessions 2, 3, 4 (see Table 7).

Table 6.

General description of activities[2]

TITLE	PHASE	DESCRIPTION	SPS	DATE
1. What do we know about magnets?	Introduction	- Magnes tale - Start the project (KWL)	- Observe - Communicate - Infer - Predict	Day 1
2. What is magnetic?	Investigation	- See magnetic things in class - Classify magnetic and no magnetic objects	- Observe - Infer - Communicate - Classify - Predict - Interpret data	Day 2
3.The strength of magnets	Investigation	- Induced magnetism	- Observe - Infer - Measure - Communicate	Day 3
4. The poles	Investigation	- Equal poles repel and different poles attract - Act at distance - Strength lines	- Observe - Infer - Predict - Measure - Communicate - Classify	Day 4
5.What have we learned?	Conclusion	- Compare what we knew with what we know - Finish the project	- Communicate - Classify - Predict - Interpret data	Day 5
6. Show to our family what we have done	Conclusion	- Summarize and remember what has been learned showing to the families	- Interpret data - Communicate	At home

[2] The activities of this proposal are developed step by step to serve as a good practice (See Annex 4).

Table 7.

Description of activities subjected to differential treatment

<table>
<tr><th></th><th>IMPOSED</th><th>DIALOGUES</th><th>LISTENING</th></tr>
<tr><td>Act 2.
What is magnetic?</td><td>Giving them a card so that they can draw on it the magnetic elements and non-magnetic that they have found in class.</td><td rowspan="2">Helping them with a questions:
What gets stuck? When they gather the material, they will be asked what they have in common, What if..? Why do you think...? What material are they made of..?</td><td>Telling them to classify magnetic and magnetic objects in the boxes</td></tr>
<tr><td>Act 3.
Strength of magnets</td><td>2nd Weak force:
How many cars, marbles, can you lift together?</td><td>1st Induced magnetism:
Have you figured out how many chips you can take?</td></tr>
<tr><td>Act 4.
Poles</td><td>The intervention will be imposed showing it what happened if… and explaining</td><td>Questions will be asked to them:
Have you tried? Why do you think? What is the difference? For what is this? What if..? Can you find a way to...?</td><td>Will have freedom to explore</td></tr>
</table>

3.5. Instruments of investigation

The tools used to carry out the collection of information from the different participants are elaborated *ad hoc*, adjusting in each case to the characteristics of the participants and their reality. Throughout all the sessions, they have been looking for evidence of the contents (better knowledge of the anatomy and way of life of ants, properties of magnets) and the development of skills. Specific purpose: to compare both between the three groups/between the three moments, to see the effect of adult intervention.

For this, photos and recordings of all interactions have been taken, which are then transcribed, analysed - content analysis – being assigning SPS or content and evaluating the degree of development. All data is anonymous (aggregated, not assigned to individuals).

In addition, drawings and written productions at different moments of the process, will serve as an instrument to see the progress of their observation and learning. Regarding the qualitative information that I have, I will examine it by means of a content analysis, which consists of categorizing, coding and classifying the data based on criteria that are put to analyse and adequately interpret the meanings of the comments made by children[3] (Martínez González, 2007).

[3] As I have made the proposal in Spanish, for the reasons outlined above, I have decided to perform the part of results and interpretation in Spanish to take full advantage of what I obtained.

Groupings:

- Class 3IE:
  - The class is divided in five groups: three groups will have a dialogue intervention, one will be listening and the last one will have an imposed intervention.
  - Each group is given an identification necklace, with the name of the group and a sticker green (Listening), orange (dialogue), red (impose). In that way they do not mix with each other and teacher know at all times which group they belong to and what type of intervention should be done (see Annex 5).
- Class 2IE:
  - The whole class together, the style changes at different times.

4. RESULTS

Propuesta 1: Hormigas

Evaluación en el conocimiento

En términos generales, y considerando juntos todos los grupos, después de la intervención se ha visto una adecuada imagen de las hormigas (anatomía, modo de vida, alimentación), además, se han superado imágenes fantásticas o estereotipadas (reina con corona, etc.) (ver Tabla 8).

Tabla 8.

¿Qué sabemos? vs. ¿Qué aprendimos?

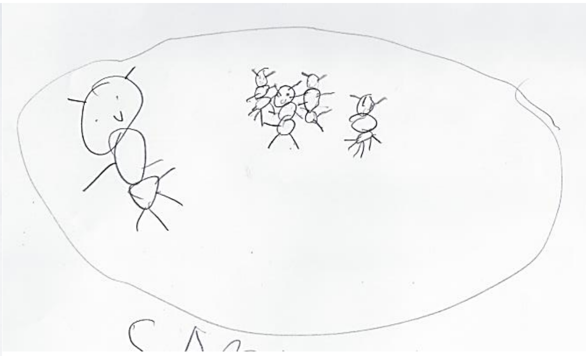
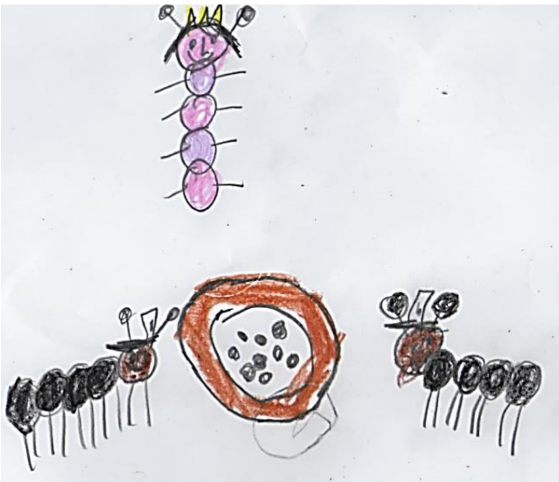
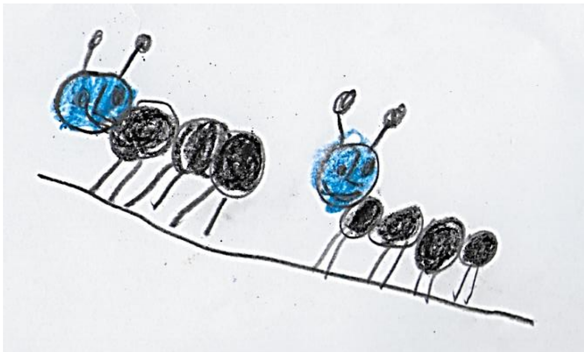
	ANTES	**DESPUÉS**
ANATOMÍA DE LAS HORMIGAS	8 patas, tienen cuernos. Nacen en un hospital.	6 patas, 2 antenas, el cuerpo está dividido en 3 partes, tienen mandíbula, larvas.
TIPOS	La reina en trono y con corona, es la hormiga más vieja. Las hormigas que pican.	Reina, soldados y obreras.
ORGANIZACIÓN	Van por separado. Viven en un hormiguero (le ponen ventanas, sofá...).	Trabajo en equipo, van en fila. Hormiguero con galerías.
ALIMENTACIÓN	Comen hojas, no saben si beben. ¿Que comen? Tomate(4) Miel(9) Galleta(3)[4]	Galleta, semillas, aguamiel, beben agua[5].

[4] Resultados de la votación en clase
[5] El hormiguero educativo viene con semillas y aguamiel.

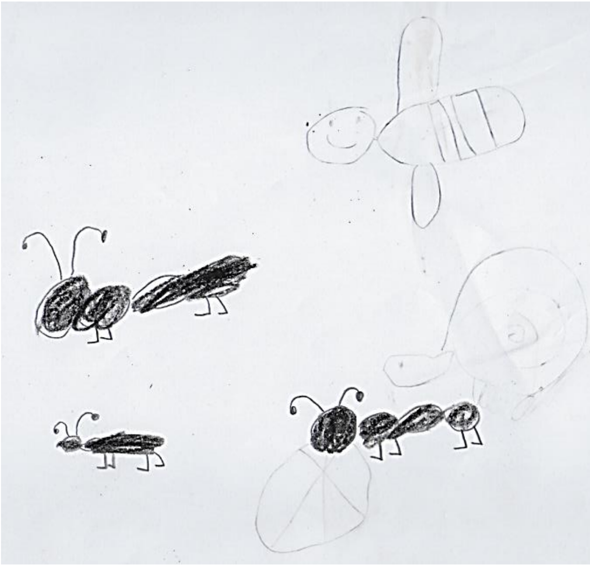
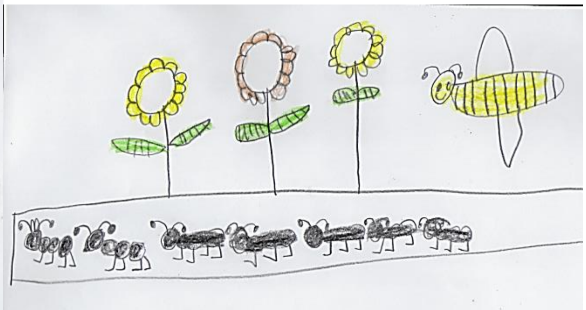
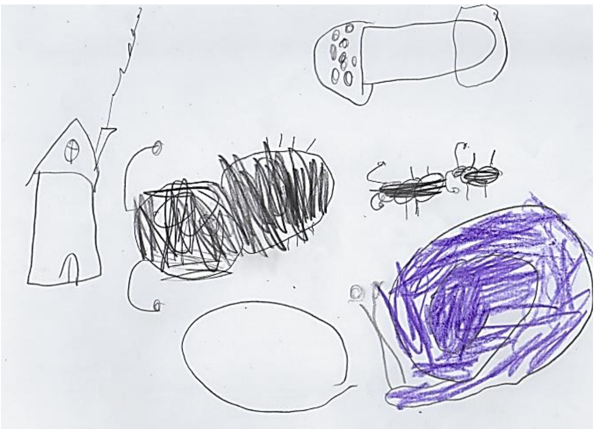
Al analizar los dibujos se ve que en el grupo guiado[6] van progresando en su observación ya que la anatomía de las hormigas cambia, la forma de organizarse también y son capaces de plasmar lo que se ha experimentado, mientras que en el directivo desde el primer momento la anatomía de la hormiga la hacen conforme se les dice, llegando a plasmar muy bien anatomía y organización. Para terminar, en el libre se ve también un cambio en cuanto la anatomía pero no se ve en la organización (ver Figura 4).

Figura 4.

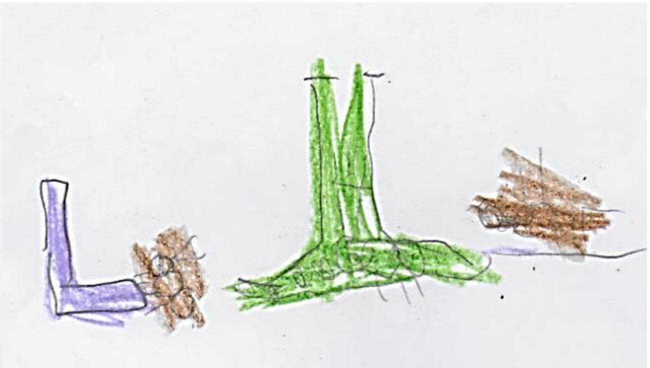
Expresión plástica de las hormigas

1ER DIBUJO (Día 1)	ÚLTIMO DIBUJO (Último día)
GRUPO GUIADO	
	
Dibuja otra cosa (no sabe qué dibujar).	Una reina y obreras (más pequeñas y muchas).
	
Reina hormiga con corona, cuerpo dividido en 5, 10/8 patas.	6 patas, en fila.

[6] El grupo guiado corresponde al *dialogue*; directivo a *imposes* y libre a *listening*.

	
Cuerpo dividido en 4, 8 patas (*tienen por detrás*), sin organización.	Cuerpo dividido en 3, 6 patas (tienen por detrás), fila de hormigas en el bordillo de la acera, dibuja una abeja igual que la primera vez pero esta vez con antenas.
	
Casa de las hormigas, cuerpo dividido en 2.	Hormiguero, cuerpo dividido en 3.
	
''Cuando frotas la mano las hormigas se iban para otro lado, por eso he puesto mi mano''.	Reproducción del hormiguero de clase.

Hormiguero y hormigas.



''Una hormiga subiendo al zapato, otra a una hoja y un hormiguero donde dentro está la reina''.

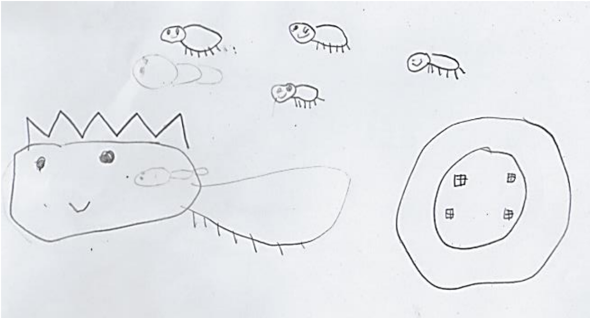
DIRECTIVO

Cuerpo dividido en 3 partes de colores, 6 patas (se le dice), hormiguero de colores, sin organización.

Hormigas negras, organizadas, y hormigueros.

Hormiga con 5 cabezas y morada (Se le dice).

Hormigas con 6 patas, 1 cabeza y en fila.

LIBRE	
	
Hormiga reina con corona, las hormigas no tienen antenas, hormiguero con ventanas.	Hormiguero con un agujero, hormiga reina más grande, muchas obreras y más pequeñas (todas llevan antenas).

Habilidades de procesos científicos

Al analizar los contenidos y el nivel de destrezas adquiridas mediante la transcripción, se ve como los estudiantes a los que les da total libertad muchas veces se desvían del tema y no son capaces de seguir la exploración, mientras que los estudiantes a los que se les guía mediante preguntas y se les deja pensar, su aprendizaje en cuanto a destrezas es mucho mayor aunque no tanto en contenidos. Para terminar, hablando de los estudiantes a los que se les implanta un nivel de intervención directiva estos son capaces de recordar a corto plazo contenidos pero el desarrollo de sus SPS apenas aumenta (ver Tabla 9).

Tabla 9.

Evidencias de desarrollo de cada una de las destrezas científicas a partir de transcripciones de las grabaciones, frases literales de los niños y niñas.

	OBSERVAR
LIBRE	Buscan ayuda: *-(E) No encuentro su casa. -(E) ¿Y cuántas patas tiene la reina?* Llamada de atención: -(E) *Mira ven, mira esta flor como se ve (Con la lupa).* Preguntas abiertas: *-(D) ¿Qué observas?* *-(E) Está cogiendo comida, hay muchas.* *-(E) Hay unas llevándose miel, y una se lleva una galleta.* *-(E) He observado, un hormiguero que era un agujero muy pequeño, que estaban entrando por fila. Iban pasándose la comida la una a las otras para llevarla a la reina.* *-(E) Que están todas las hormigas con la reina.*

	Pierden el hilo: *-(E) ¡Un patinete! (estudiante) Estamos buscando un hormiguero no un patinete (profe).* *-(E)* Quiero hacer algo con la cámara, me aburro con la lupa, yo ya he mirado a las hormigas. Pregunta de observación: *-(E) ¿Por qué no ponemos un poco más de galleta? (D) ¿Para qué? Si ya tienen (E) Porque se la están comiendo.*
GUIADO	Preguntas productivas: *-(D) ¿Qué tipo de hormigas serán estas? ¿Será la reina? (E) No (D) ¿Por qué? (E) Porque son muy pequeñas. (D) ¿Sino es la reina, qué clase de hormigas serán? (E) Las ayudantes de la reina. (D)¿Y qué harán? (E) Buscando comida.* *(D) ¿Queréis observar algo más? (E) Yo sí, mira esta se ha subido por aquí.* Preguntas para focalizar la atención: *-(D) ¿Hacia qué lado van las hormigas? (E) Una para cada lado.* *(D) ¡Mira!, voy a pasar mi mano para ver qué pasa… ¿Qué está pasando? (E) Que se están cambiando de dire-dirección, que se ha dado la vuelta, se va para otro lado.* *-(D) ¿Te has fijado como cogen la comida las hormigas? (E) Lo coge con la cabeza y las patas de adelante, La coge con la boca, tiene unas pinzas*. *-(D) ¿Os habéis fijado cuántas patas tienen? (E) 6 (D) ¿Y cómo tienen el cuerpo? (E) Dividido en 3 y tiene cuernos (D) ¿Son cuernos?* *- (E) Yo no les veo su cara. ¡A sí! Está donde las antenas. ¡Mira! esta solo tiene una antena.* *-(D) ¡Mirar! ¿Qué se está llevando esa hormiga? (E) Un trozo de galleta (D) No.* *(E) ¿Eso blanco que es? (D) De donde nacen las hormigas (E) De eso blanco ¡Ahhhh! se está llevando a su hija (D) Una larva (E) ¡Se la están comiendo, se están peleando!* Descripción de hechos: *-(E) Una hormiga está en la lupa (D) Aprovecha y obsérvala.* *- (E) ¡Un hormiguero, están entrando las hormigas!* *-(E) Cuando las hormigas se cambiaban de lado yo observé con la lupa que se subía una encima de la otra y después bajaba.*
DIRECTIVO	Explicaciones directas: *-(D) Mira, vamos a fijarnos como tienen el cuerpo (pongo la lupa cerca) tienen 6 patas, su cuerpo se divide en 3 partes, tienen antenas y mandíbula.* *- (E) ¡Mirar el hormiguero! Es una manada de hormigas. (D) Sí, una colonia. (E) Una colonia de hormigas.* *-(D) Hemos puesto tomate, galleta y miel y vemos como hay más hormigas que se llevan la galleta.* *-(D) Vamos a buscar juntos un hormiguero. (E) Aquí hay uno (D) Vale, vamos a sacarle foto. Sale tu sombra y no se ve bien muévete un poco.* *-(D) Mirar las hormigas cogen la comida con la mandíbula, fijaos, que tienen unas pinzas.* *-(D) ¿Ves eso de ahí blanco? Son larvas. ¿Te fijas? ¿Has visto cómo las protegen?* *Describen hechos:* *-(E) Ha salido una del hormiguero.* *-(E) Profe mira, se están llevando la galleta.*

	-(E) Tengo 2 hormigas en la mano (P) Sácales foto.
	COMUNICAR
LIBRE	Comentarios: *-(E) Les voy a ayudar a hacer un hormiguero.* *-(E) ¿Dónde estará el hormiguero?* *-(E) ¿Qué tal si dentro de todos los hormigueros hacemos una foto?* Preguntas abiertas: *-(D) ¿Para qué sirven las lupas? (E) ¿Para ver cosas minis? No se cómo se usa.* *-(D) ¿Qué me puedes contar? (E) La reina está tumbada y las otras le llevan la comida, están cogiendo un montón de semillas.*
GUIADO	Conceptos aprendidos: *-(D) ¿Qué pasaba cuando frotamos en el suelo con nuestra palma? (E) Pues que, como nuestra mano huele a otra cosa ellas se iban por otro lado se volvían o rodeaban, no con la uña frotando con la palma o el dedo, pero no pasaban por donde habíamos frotado la mano.* *-(E) He dibujado que como frotamos las manos estaban yendo para otra dirección.* *-(D) ¿Cuántas patas tienen las hormigas? (E) 6 pero le dibujé 3 porque las otras estaban al otro lado.* *-(E) Yo ya sé cómo es sin fijarse: las hormigas tienen 6 patas y yo sé que el cuerpo van así y lo tienen redondo de 3 partes, tienen ojos chiquititos pero nosotros no los vemos.* Recordando: *-(D) ¿Qué hicimos ayer en el patio? (E) Buscamos un hormiguero, encontramos debajo de un árbol un hormiguero que había muchas hormigas, a mí se me subieron las hormigas al zapato.*
DIRECTIVO	Explicaciones: *-(D) Las hormigas se giran porque al pasar mi mano por su recorrido huele diferente.* *-(D) Las hormigas que defienden el hormiguero son las soldados.* *-(D) Las hormigas van en fila.* Aplicación de lo aprendido: *-(E) He dibujado el hormiguero, y las hormigas yendo.* *-(D) ¿Cómo tiene el cuerpo? (E) Sabemos que tienen 6 patas (D) ¿En la cabeza tienen orejas? (E) Noo, antenas y luego también mandíbulas. El cuerpo tiene 3 círculos.* *-(D) ¿Dónde está la reina siempre? Al fondo del hormiguero las soldadas le protegen.* Conocimientos previos: *-(E) Las avispas van a las flores, lo llevan al abejero y hacen la miel (D) Las abejas, sí.*
	PREDECIR
LIBRE	Discursos entre compañeros: *-(E1) ¿Pueden llorar las hormigas? (E2) No sé.* *-(E1) ¡Mira estoy viendo miguitas aquí de hormigas! ¿Será que alguna le habrá matado a alguna? (E2) ¡Serán cacas de hormigas!* (E1) *¿Cómo van a hacer cacas? (E2) ¡Las hormigas cagan! (E1) Las hormigas cagan huevos. (E2) No, yo creo que no. (E1) Otro día tenemos que mirar a ver si han sacado un huevo.* -(E) *Las hormigas están recogiendo comida para la reina, esta está matada (Ven a la hormiga en el hormiguero que no se mueve).*
GUIADO	Conocimientos previos: *-(E) Aquí no hay hormigueros, igual hay más por el huerto.* *-(D) ¿Cómo podemos hacer para que cambien su dirección? (E) No sé.*

	Suposiciones: *-(D) ¿A dónde van estas hormigas? (E) A su casa.* *-(E) Aquí no hemos visto hormigas rojas, hay que buscarlas, aunque igual no hay.* *-(E) Otra vez se va la reina, igual va a comer un poco*. Dan atributos fantásticos: *-(D) ¿Habéis visto una reina? (E) No, es que quiero buscar una reina para echarle una foto (D) ¿Y entonces dónde estará la reina? (E) No se estará echando la siesta…* *(D) ¿Porque había hormigas soldados? (E) Yo ya lo sé, las soldadas estaban allí para proteger a la reina (D) ¿Y dónde estaba la reina? (E) En un trono (D) ¿Tiene corona y tiene trono? (E) No, es que no sé, es que lo vi en una película de hormigas.*
DIRECTIVO	(X)
	INFERIR
LIBRE	Suposición: *-(E) Me han mordido porque les he tocado su hormiguero.*
GUIADO	Conocimientos previos: *-(D) ¿Por qué crees que están corriendo? (E) Porque están asustadas.* *-No quitamos el tubo porque si no se escapan.* *-(D) ¿Por qué les cuesta tanto a las hormigas entrar? (E) Porque la reina hormiga entró un día aquí, miro a ver si había algo malo y dijo la reina: vestigar, vestigar y ahora están investigando. (D) ¿Y tú crees que no les ha dado tiempo aún de investigar? (E) Tienen que investigar más, aún están investigando.*
DIRECTIVO	Producción ``avanzada´´ después de explicación: *-(D) ¿Por qué está la reina en el fondo? (E) Porque la están protegiendo.*
	INTERPRETAR DATOS
LIBRE	Experiencia previa: *-(E) Las hormigas comen hojas.* *-(E) Las rojas pican y muerden y las negras solo muerden.*
GUIADO	Conocimientos previos: *-(E) Las hormigas hacen el hormiguero con hojas.* *-(E) Si no les hacemos nada no nos pican.* *-(E1) ¿Vamos a dibujar las hormigas? (E2) Ahora nos dirá la profe. (E1) ¿Y porque ha traído hojas entonces?* *-(E1) Mira un hormiguero (E2) Ósea eso significa que debajo de las plantas hay muchos hormigueros.*
DIRECTIVO	(X)
	CLASIFICAR/MEDIR
LIBRE	*Diferentes dimensiones:* *-(E) Con la lupa, esta se ve como la reina y la reina más grande.* *-(D) Dibuja cómo crees que es por dentro un hormiguero (E) ¿Cómo voy a entrar a uno para verlo?*
GUIADO	Producciones avanzadas *-(D) ¿Son todas las hormigas iguales? (E) No, la reina es la más grande, es tan grande que casi no cabe en el tubo y hay otras más grandes que otras.* *-(D) ¿Son todas las hormigas iguales? (E) Si, son todas negras (D) ¿Y de tamaño? (E) No, hay unas chiquititas, otras medianas y la reina hormiga más grande.* *-(D) ¿Qué son esto? (E) Hormigas. (D) ¿Y cómo andan estas hormigas? (E) Ah, 1, 2, 3, 4, 5 y 6 (le dibuja las patas).*

DIRECTIVO	(X)
	FORMULAR HIPÓTESIS
LIBRE	(X)
GUIADO	Experiencia previa: *-(E) ¿Y si vienen las avispas a por miel?*
DIRECTIVO	(X)

Nota: (D) Habla docente, (E) Habla estudiante, (X) No se han encontrado evidencias.
La línea más gruesa separa las *BPS* de las *IP.*

Además todo esto también se ha podido observar en la toma de fotos ya que a los estudiantes a los que se le dejaba libre se desvían del tema central y se ponían a hacer fotos de flores, a los amigos y con poca calidad, lo que nos dice que no saben muy bien qué observar, aunque que se les había dado la consigna de buscar hormigas (ver Figura 5a). Sin embargo cuando les haces preguntas productivas para guiarles o les decías cómo tenían que hacerlo muestran hormigas solas, en grupo, en su hábitat… (ver Figura 5b).

Figura 5.

Fotos realizadas por alumnos

a

b

Nota: a – Fotos; b - Fotos de calidad

Realizando el análisis de los diferentes grupos (directivo, libre y guiado), se puede ver como existen diferencias en el aprendizaje de SPS debido a las diferentes intervenciones que el adulto realiza en cada uno de ellos. En la intervención directiva se puede ver como son capaces de adquirir muchos conceptos a corto plazo pero carecen de desarrollo de las SPS, en la libre vemos como el desarrollo que hacen en SPS es nulo, adquiriendo únicamente conceptos básicos y por último, en el guiado podemos ver como el nivel de destrezas aumenta significativamente, adquiriendo además algunos conceptos (ver Tabla 10).

Tabla 10.

Comparación entre grupos

	HABILIDADES DE PROCESOS CIENTÍFICOS	CONCEPTOS FINALES APRENDIDOS
LIBRE	Se quedan a un nivel superficial con una observación - anatómicas. Inferencias.	Conceptos básicos: 3 partes, 6 patas, 3 tipos. Han sido aprendidos por su observación.
GUIADO	Adquiere el tope que se pide, se les ayuda a observar, pensar mediante preguntas...	Adquiere algunos conceptos más relacionados con lo que se ha aprendido a través de los procesos científicos: Observación de hormigas en fila, reina, ayudantes, partes de las hormigas…
DIRECTIVO	Las habilidades científicas no se desarrollan, únicamente las que se ponen de ejemplo para la adquisición de conocimientos como la observación con lupa.	Máxima adquisición de conceptos: Partes de una hormiga: antena, mandíbula..., alimentación, organización... Adquirido a partir de la explicación que se da.

Propuesta 2: Imanes

<u>Conocimiento:</u>

Materiales magnéticos:

Respecto al primer contenido a alcanzar, distinguir materiales magnéticos de no magnéticos, los niños y niñas constataron que la magnetita se pegaba y las piedras normales no, razonando que “se pega porque es pegajosa” (ver Figura 6 a).

A continuación, los niños y niñas buscaron elementos magnéticos por la clase; si bien en los primeros momentos se condujeron por ensayo y error (ver Figura 6 b), después fueron capaces de deducir patrones (metálico = magnético) (ver Figura 6 c), y de clasificar los diversos objetos en función de este criterio (Figura 6 d). Al terminar, representaron y así formalizaron esta clasificación (ver Figura 7).

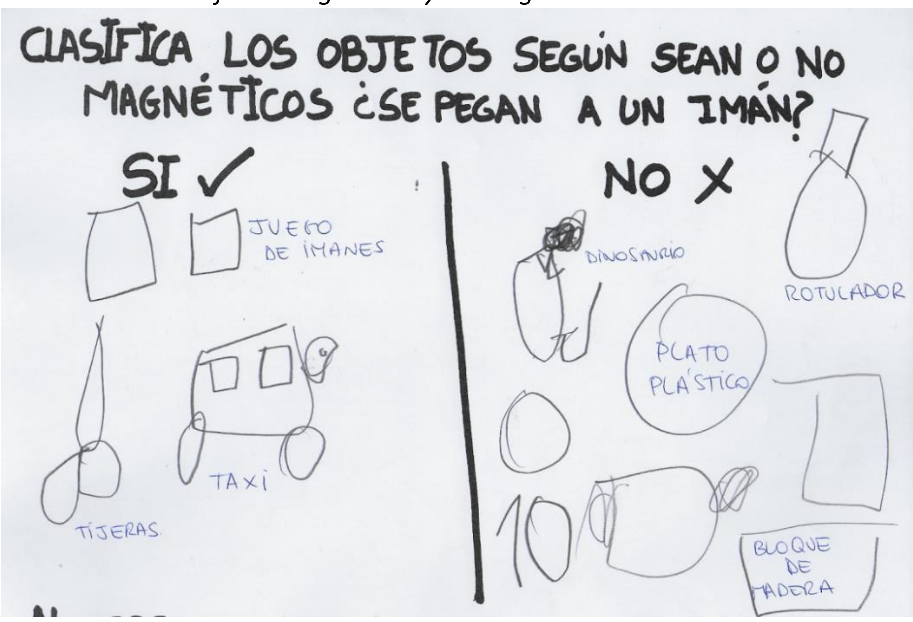
Figura 6.

¿Qué es magnético?

Nota: a - Piedra vs. Magnetita; b - Al azar; c- Sólo magnéticos; d – Clasificamos.

Figura 7:

Expresión plástica sobre los objetos magnéticos y no magnéticos



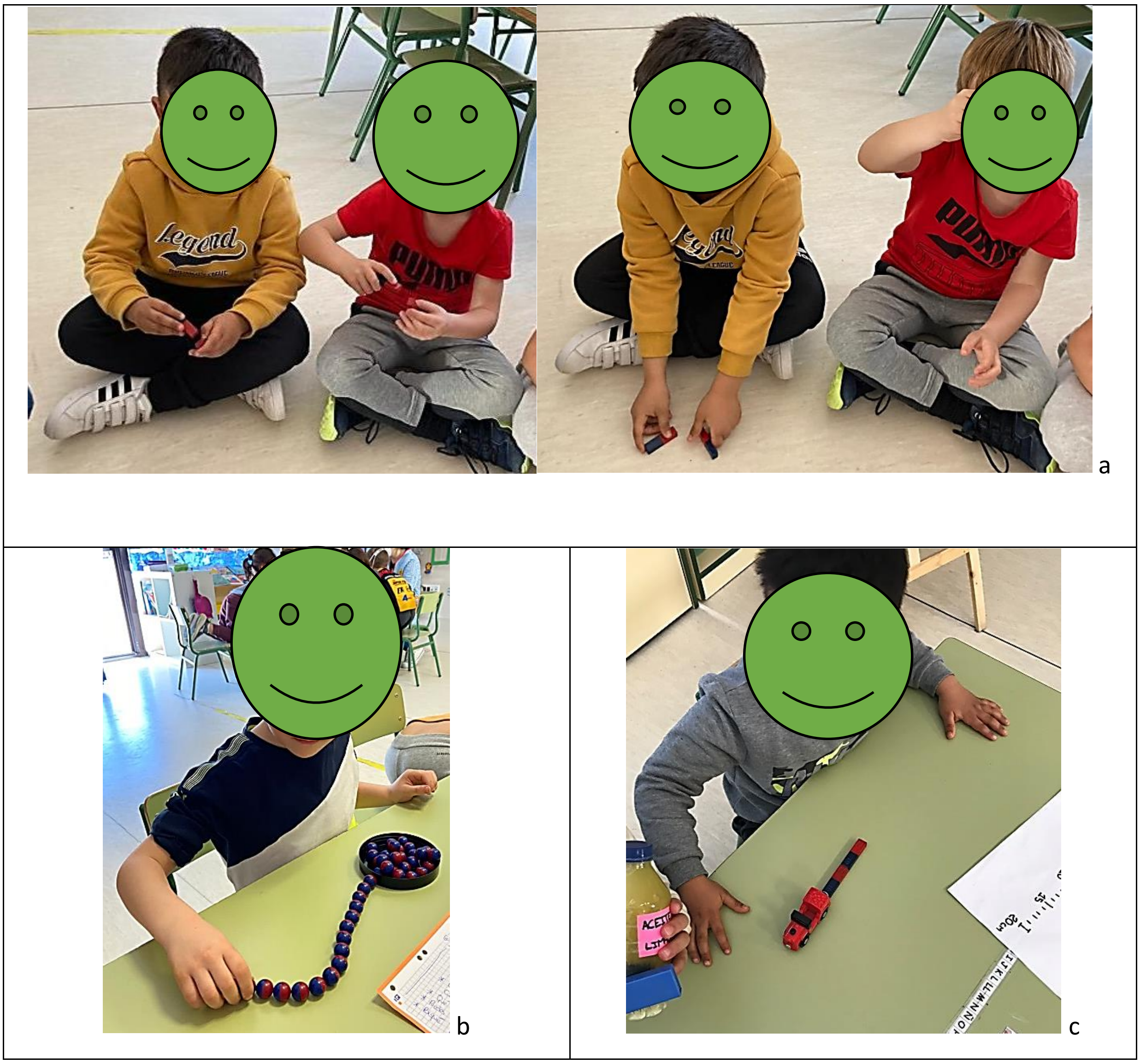
Polos:

Respecto al segundo contenido a alcanzar, saber la existencia de dos polos, los niños y niñas en asamblea, constataron que los colores tienen un significado ya que rojo pega con azul (ensayo-error), razonando que “existe una fuerza que les obliga a darse la vuelta” (Ver Figura 8 a).

A continuación, con las canicas magnéticas en los rincones, los niños y niñas descubrieron como únicamente la parte roja pegaba con la azul (Ver Figura 8 b); Además se dieron cuenta que se pueden juntar diferentes elementos (Imanes y trenes). Por esto, los objetos magnéticos aunque no tengan color también se pegan a uno de los polos = color no es lo que les da el carácter magnético (Ver Figura 8 c).

Figura 8.

Descubriendo los polos



Nota: a – Polos; b – Canicas; c – Imanes y trenes

Polos actúan a distancia:

Respecto al tercer contenido a alcanzar, ver como los polos actúan a una cierta distancia, los niños y niñas en los rincones, constataron que aunque no se toquen el imán atrae a las limaduras de hierro para ponerle pelo a Jon y también es capaz de hacerlo en una botella con aceite y limaduras, razonando que “cuando están cerca se pegan solos” (ver Figura 9 a, b).

A continuación, en la asamblea, repasamos a que distancia se juntan los diferentes imanes y por qué (tienen diferente intensidad) (ver Figura 9 c).

Figura 9.

Comprobando cómo los polos actúan a una cierta distancia

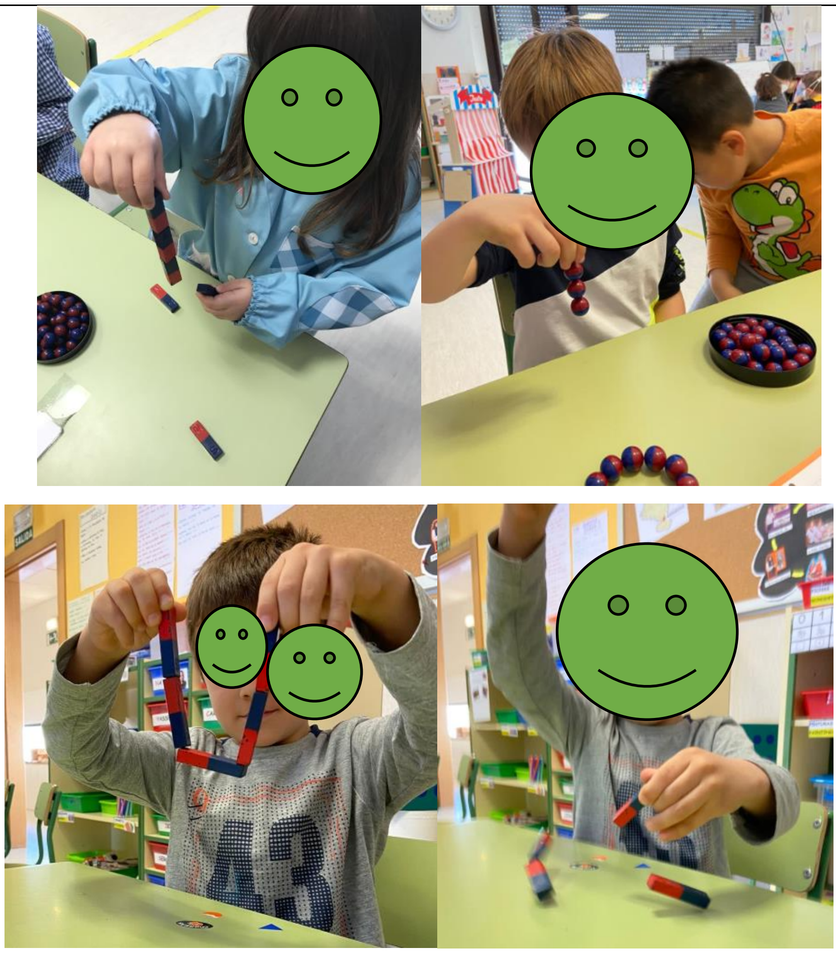
Nota: a – Le ponemos pelo a Jon; b – Aceite y limaduras; c – Asamblea ¿A qué distancia se juntan?

La atracción magnética es una fuerza débil:

Respecto al cuarto contenido a alcanzar, descubrir que el magnetismo no puede a la gravedad, los niños y niñas en los rincones, constataron que cuando se llega a un cierto número de imanes colgando, estos se caen, razonando que “cuando se juntan muchos se caen” (ver Figura 10 a).

Figura 10.

¿Cuántos imanes puedo levantar?



a

Nota: a – Levantando imanes

Magnetismo inducido:

Respecto al quinto contenido a alcanzar, descubrir que se puede hacer que algo que no es magnético lo sea, los niños y niñas en los rincones, constataron que se puede imantar una aguja y que cuando las fichas son atraídas por un imán se pegan entre ellas ya que tienen una parte de hierro, razonando que “Con la aguja solo podemos coger una y con el imán muchas” (ver Figura 11 a, b).

Figura 11.

Hacemos que algo no magnético pase a serlo

a

b

Nota: a – Imantamos un aguja; b – Imán y fichas

El campo magnético establece líneas de fuerza:

Respecto al último contenido a alcanzar, descubrir que se pueden ver las líneas de fuerza que generan los imanes con su campo magnético, los niños y niñas en los rincones, constataron que se puede ver las diferentes formas que adquiere las limaduras al poner un imán por debajo de la caja de papel, razonando que "Están bailando" (ver Figura 12 a).

Figura 12.

Observamos líneas de fuerza

a

Nota: a – Líneas de fuerza

Haciendo una valoración global sobre lo aprendido vemos que identifican magnético con metálico: el imán atrae "al hierro" (nombre genérico para todos los metales), y que además al resto de sustancias ''Se pega solo en metal''. También se ve que han comprendido la existencia de dos diferentes polos uno que se atrae y otro que se repele y que estos polos son capaces de actuar a distancia ''*Las virutas de hierro aunque estén en aceite las atrae el imán*'' (ver Tabla 11).

Tabla 11.

Valoración global de evidencias sobre lo que han aprendido a partir de transcripciones de las grabaciones, frases literales de los niños y niñas.

	ANTES	**DESPUÉS**
¿CÓMO SEPARAMOS LIMADURAS DE HIERRO DE BICARBONATO?	Intentos frustrados: *Con el dedo, no sé, cogiéndolo, con unas pinzas especiales de hierro/médico.*	El Imán atrae al hierro: *Con el imán.*
MATERIALES MAGNÉTICOS	Características sin relevancia: *Se pegan porque es pegajoso, son duros, son secas, en la madera, no se pega porque es rosa.*	Magnético= metálico: *Se pegan solo en metal, hierro, es magnético.*
POLOS	No entienden por qué pasa: *Porque se vuelven solos y se juntan parece que tienen pila, es difícil juntar el rojo con el rojo, se me intentan pegar, se escapa, se mueve solo, los dejas apartados y se juntan solos.*	Existen dos polos: *Los diferentes (opuestos) se pegan (atraen), los iguales no se pegan (repelen), los imanes tienen dos polos: norte y sur.*
POLOS ACTÚA A DISTANCIA	Actúa a una cierta distancia: *Cuando están cerca se pegan solos.*	Actúa aunque no se puedan tocar: *Las virutas de hierro aunque estén en aceite las atrae el imán.*
FUERZA MAGNÉTICA	Los imanes solo sirven para pegar cosas: *Para pegar*	Atracción y potencia diversas: *Atrae cosas, unos imanes tienen más fuerza (Potencia) que otros.*
LA ATRACCIÓN MAGNÉTICA ES UNA FUERZA DÉBIL	Idea previa(fuerza de la gravedad): *Cuando se juntan muchas se caen.*	Comprobación y variantes: *Se pueden levantar 2 coches, 5 canicas y 4 imanes, más no.* *(Fuerza de la gravedad más intensa que la magnética)* *Si lo coges de los dos lados no se rompe.*
MAGNETISMO INDUCIDO	No existe posibilidad: *No es posible que en una aguja se pegue el hierro, las fichas no se pegan entre sí.*	Potencia de la aguja e imán: *Con la aguja sólo podemos coger una ficha y con el imán muchas.*
EL CAMPO MAGNÉTICO ESTABLECE LÍNEAS DE FUERZA	Características sin relevancia: *Las limaduras de hierro están bailando.*	Adquisición de conocimientos: *Podemos juntar las limaduras con el imán (fuerza que atrae).*

Habilidades de procesos científicos:

Al analizar las destrezas, se ha podido ver gracias a las evidencias, como los niños y niñas son capaces de desarrollar destrezas científicas básicas e integradas ya que en este caso, son capaces de hacer inferencias y predicciones en algunos casos acertadas. También se ha visto cómo pueden llegar a formular sus propias hipótesis: *¿Y si hacemos así? Se pegará* (ver Tabla 12).

Tabla 12.

Evidencias de desarrollo de cada una de las destrezas científicas a partir de transcripciones de las grabaciones, frases literales de los niños.

SPS	EVIDENCIAS
OBSERVAR	Describen por parecidos con cosas de su vida cotidiana: *(E) Parece zumo - es una araña - parece un pez - parece barba.* Describen comportamientos de los materiales: *(D) ¿Qué pasa cuando pones el imán cerca de las limaduras de hierro del bote de aceite? (E) Que se atraen, que se ven, es mágico.* *(E)Se pega mucho esto.* Atribuyen a la magia y no a la ciencia: *(D) ¿Qué ha pasado? (E) Se ha pegado, es magia.*
INFERIR	Porque sí/ porque no: *(D) ¿Se va a pegar por los dos lados del tren?* *-(E) No. (D) ¿Por qué no? (E) Porque yo tengo en mi casa y se juntan todos.* *-(E) Sí, porque es de color plata, porque son imanes.* *Se parte un imán: (D) ¿Podremos juntar el azul con el azul? (E) No (D) ¿Por qué? (E) Porque son iguales.* *(D) ¿Por qué te pegas? (E) Porque sí.* Por propiedades del material: *-(D) ¿Porque se pega al plato y al cuchillo no? (E) Porque es de metal, porque es magnético.* *-(D) ¿Por qué se pega esta cesta al imán? (E) Porque tiene/es hierro.* *-(D) ¿Porque este imán se pega cuando está a 3 cm? (E) Porque es más fuerte, porque es más grande (Tienen más potencia, profe).* *-(D) ¿A qué distancia crees que se va a pegar? (E) A 5. (D) ¿Por qué? (E) Porque es diferente.*
PREDECIR	Se pegará/ no se pegará = qué es metálico y qué no lo es: *(D) ¿Cómo crees que podemos atraer las limaduras de hierro del bote de aceite? (E) Con unos imanes, se queda el aceite amarillo de nuevo.* *(D) Y si quito el imán de la botella ¿qué pasará? (E) Que se suelten, se vayan.*

	Producciones "avanzadas" después de haber pasado por los rincones: • polos • fuerza magnética *-(D) ¿Cómo podemos juntar las limaduras? (E) Con el imán azul. (D) ¿Y con el otro? (E) Este tiene más potencia.* *-(D) ¿Y si juntamos rojo con rojo? (E) No se pegan.* Conocimientos previos: *-Agitamos la botella de aceite: (D) ¿Cómo podemos hacer que vuelva a ser amarillo? (E) Sin moverlo.* *-(D) ¿Se pegará la aguja una vez que pasamos el imán? (E) No, porque es para pinchar. Es como pescar peces.* *-(D) ¿Qué pasa si levantas estos 4 imanes? (E) Que se caen, que se rompen. (D) ¿Y con tres? (E) Creo que no se caerá (D) ¿Por qué? (E) Porque 5 es más. Porque ya hay muchas. Porque pesa muchísimo.* *-(D) ¿Qué estás haciendo? (E) Una fila (D) ¿Has probado a levantarlos? (E) No (D) ¿Crees que van a aguantar? (E) Si (D) ¿Intentamos poner otro más? (E) Si*
MEDIR	Producciones "avanzadas" después de haber pasado por los rincones: • Actúan a distancia *(D) ¿A qué distancia se pegan los imanes? (E) A de cerca, cuando los pones un poquito juntos. (D) ¿Cuánto 1, 2 ,3...cm?* Si/ No: *(D) ¿Y si cambiamos de imán? ¿Se pegaran a la misma? (E) No sabemos.* Conocimientos previos: *(D) ¿Cuántos imanes puedes levantar? (E) Si hay muchos no se pegan. (D) Prueba con 2, con 3…*
COMUNICAR	Precisión términos: atraer/repeler *-(D) ¿Qué está pasando? (E) Se vaya (Se repele).* *-(D) ¿Qué podemos hacer con el frasco con limaduras? (E) Nada (E2) Yo sé (coge un imán).* *-(D) ¿Qué has averiguado? (E) Muchas cosas: que el imán se pega a las limaduras y también he averiguado esto: con la cara le pongo el pelo loco.* Aparición de términos aprendidos: Cosas magnéticas *-(D) ¿Qué estás haciendo? (E) Buscar las cosas que se pegan. (D) ¡Si, las cosas magnéticas!* *Causa/Consecuencia - razón:* *-(E) Si lo coges de los dos lados no se rompe (D) ¿y si lo coges de uno? (Lo prueba y se rompe).* *-(E) Estoy intentando recoger, pero no me dejan en paz los imanes.*
CLASSIFICAR	Imanes con diferentes fuerzas magnéticas: *(E) El azul es más potente, tiene más fuerza.* Objetos que se pegan al imán y los que no: hierro. *(D) ¿Qué tienen en común? (E) Que los dos son de hierro.*

FORMULAR PREGUNTAS	Duda: (E) *¿Por qué el blanco no se pega?*
FORMULAR HIPÓTESIS	Prueba y error: *-(E) ¿Si hacemos así? (Lo dice para poner el imán encima de la caja de papel con limaduras) (D) Yo lo estaba pasando por debajo.* *-Al imantar la aguja, probaba en la parte de color de las fichas ya que solo tenía una y estaba imantada: (E) ¿Y en lo dorado? ¿Puedo intentarlo?* *-(E) ¿Se pegan las virutas que hay en la caja de la magnetita al imán grande?*
INTERPRETAR DATOS	Organización de datos para sacar conclusiones: *-(E) Aquí hay pocas cosas y aquí hay muchas, estas cosas se pegan y estas no.* *-(D) Muy bien chicas (E) Solo las chicas lo adivinan.*

Nota: (D) Habla docente, (E) Habla estudiante.
La línea más gruesa separa las *BPS* de las *IP.*

Se ha visto, como el tipo de preguntas que se hagan determina la calidad de las respuestas, asumimos que hay calidad de la comprensión del concepto. De la observación a lo interpretativo, no sólo qué sucede, sino también por qué razones (ver Tabla 13).

Tabla 13.

Respuesta de los niños ante preguntas abiertas y/o productivas

	PREGUNTA ABIERTA	PREGUNTA PRODUCTIVA
OBSERVAR	Pega	No, se pega solo al hierro.
INFERIR	Porque es magnético	Porque lo magnético es atraído por el hierro.
PREDECIR	No se pega	No se pega porque los polos iguales se repelen.
MEDIR	Se pega a 3 cm	Se pega a 3cm porque tienen diferente potencia.
COMUNICAR	El imán se pega	El imán se pega a las limaduras de hierro porque las atrae.
CLASIFICAR	Los que se pegan al imán y los que no	Los objetos que se pegan al imán porque son de hierro y los que no se pegan porque son de otros materiales.

Nota: Preguntas productivas se entiende por aquellas que pueden servir de indicador de problemas y dan información sobre el pensamiento (Chin & Obsborne, 2008).

Realizando el análisis de las diferentes fases (Directiva, libre y guiada), se puede ver como existen diferencias entre las diferentes intervenciones que el adulto realiza en cada una de ellas. En la fase directiva se puede ver como son muy dependientes de valoración externa; en la libre vemos como el desarrollo que hacen es nulo y en la de guiado podemos ver como el nivel de destrezas aumenta haciendo mejor observaciones (ver Tabla 14).

Tabla 14.

Comparación entre fases

FASE	SPS
DIRECTIVA	La maestra da la solución por lo que acaba el juego. – Aún más inseguros, no se les deja pensar. *(D) ¿El hierro a donde se pega? Empieza el alumno a decir eeee y la profesora de referencia de una de las clases dice: al imán, dándole la solución. Además se nota que en esa clase los alumnos son más inseguros ya que en repetidas ocasiones van a la profesora de referencia a decir ¿qué hago? No sé qué hacer…* – Aprenden contenidos.
LIBRE	Exploran un tiempo pero: – se quedan enseguida sin ideas, se cansan antes. *¿Cuándo cambiamos? ¡Quiero ir a otro rincón!* – piden instrucciones de qué hacer, a dónde ir. *¿Yo que hago? ¿Y a mí que me toca?* – piden permiso. *¿Puedo ir a otro rincón a buscar cosas magnéticas?* – buscan aprobación. *¿Esto te gusta?* – se sienten inseguros con materiales nuevos, a veces no son capaces de animarse a explorar. *¿Qué hago con esto? ¿Y esto para qué es?* – intentan llamar la atención de la profe. *¡Profe ven! ¡Mira lo que estoy haciendo!*
GUIADO	Les ayuda a reflexionar y pensar (Ver Tabla 14). – Desarrollan un mayor número de destrezas. *(D) ¿Qué es un imán? (E) Una cosa que se pega (D) ¿Dónde se pega? (E) En el hierro (D) ¿Y por qué se pega al hierro y no a la madera? (E) Porque es un metal, y a los imanes les atrae el hierro.* (E) ¡Prueba en lo oro!

Nota: (D) Habla docente, (E) Habla estudiante.

DISCUSSION AND CONCLUSION

Contrary to the commonly held belief, this proposal has shown that infant children are able to think scientifically and progress in their scientific thinking (Robbins, 2005), understanding some a priori complex concepts such as ‘‘poles attract or repel’’.

Moreover, throughout the proposal the children have demonstrated a progression in the use, although none of these skills have been fully developed, since, the acquisition of skills is a lifelong process, and also the process was carried out in a short period of time and with different forms of adult intervention. However, these skills can be developed (Ibarra et al. 2010), if children are given appropriate contexts (Sutton-Smith, 1970).

It has been seen how the development of scientific skills has increased especially in the intervention of dialogues, starting from an interesting topic for the students, asking them productive questions and giving them a good context to carry out their research (adequate classroom climate), providing them instruments and materials such as magnifying glasses and marbles of magnets, which has made that their interest increases.

As we have seen, and as already Maruyama et al. (2014) pointed out, intellectual development starts from children's previous knowledge and is complemented by the continuous interactive experience, which is essential for the creation of new patterns. But this experience does not directly generate knowledge (Hodson, 1994), there needs to be an intellectual game behind it (Couso, 2014). For this, the intervention of the adult guiding the class talk is crucial (Harlen, 2018).

Therefore, there are different ways for adults to carry out their intervention with children. In both proposals, three contrasting types of intervention have been carried out differently.

Now we are going to explain them in detail to see what has happened in the implantation of each one to see the impact of adult intervention on the engagement with science tasks and their impact on learning, which is one of our main objectives.

In the proposals, it is shown that the children who were guided with a dialogue intervention, have been the ones who have acquired the highest level of SPS, since their level of interest in exploration increased due to the questions and challenges that were being set (Bonawitz et al. 2010). That is very good since the learning of SPS concepts are the basis for solving the problems of our outside world (Siayah et. al. 2019). If the focus is on the acquisition of SPS, does not mean that the contents are left aside, but rather that the SPS are prioritized, due to the importance they have and the learning of contents will be acquired through these and the help of the teacher.

Furthermore, in the proposals it is also clearly seen how the type of questions that are asked is crucial for the development of good thinking, this coincides with what was published by Elstgeest (1985). On one hand, when open questions are asked they do not lead to a thought since they are simple and can be answered without thinking. On the other hand, when questions are asked to focus their attention or find a solution, the answers are much more accurate and complete (see Table 13). In addition to asking good questions, language is crucial and the introduction of new terms at the right time to help students to be more precise and understand the meaning is a very important factor as Harlen (2018) explains in his work. It has been seen how this works in both proposals. Words such as ‘‘poles’’, ‘‘attract’’ and ‘‘larvae’’ are of vital importance since it is necessary to introduce these new concepts to help children to expand their knowledge, generate better explanations and extend their thinking.

To end up with this type of intervention that dialogues, scientific thinking is of vital importance and the responsibility that the teacher has for it, in helping students to open the mind, hook them with open but productive questions following the scientific method and education by inquiry, as it makes children critical and empowered of their learning (Fine & Desmond, 2015). Therefore, following a correct organization of the phases as it is shown in our proposal is basic, as indicated by Pedaste et al. (2015).

Regarding the children who were imposed the curricular knowledge, it has been seen that they have been able to learn all the contents, but taking in terms of SPS they have been left behind. They only stay in the stage of imitating the adult without going through exploration many times since they are told the possibilities that a magnet has, in this case, and they are not allowed to explore further. The predictions that they make are null or scarce since they are not allowed to think and reflect nor are they helped to do so which makes children inactive subjects. Furthermore, another aspect is that they require external validation all the time.

Speaking about listening intervention, what has been seen is that children can explore for a while but with certain limitations since they are not able to go one step further without the help of the adult, it remains at a very superficial level in terms of SPS and only acquire the basic concepts, the ones that they have been able to extract. One thing that has been seen repeatedly is that they give their answers superficially and are not able to describe the properties of something in detail. All this, agrees with Vigostki's theory, children need adult help to move to a higher stage of development (ZPD).

What you see is that, it is very difficult to do science if, from the age of 4, they are so focused on content and not on SPS as they lose their natural curiosity, what later results in little significant learning for them, which is what causes the most school failure, as pointed out by Fine & Desmond (2015). Even though, all of the different interventions have been provided with a suitable environment to develop the exploration in the proposals, taking into account materials, and the indications of Santer et al. (2007). Furthermore, it should be noted the importance of also having an adult to guide as Yeam (2007) states, to build an environment to foster the development of SPS.

If from the first stages of their life they are given that base of SPS, their evolution will be greater and they will be better prepared to interpret the world as Harlen (1999) comments. In our proposals it is seen that critical thinking and reasoning is sometimes scarce since children are not very used to being asked for reflection and on many occasions they prefer not to answer for fear of a bad repercussion of their answer. What is more, this was the first time that the students faced a science-related project, which makes us see that despite the fact that it is said that education is changing, we still have a long way to go, to provide students with the necessary tools and not just fill them with meaningless content. Since few are those who dare to introduce science in the early childhood classroom, for fear of thinking that infant children are so young and they cannot do it or they just don't feel ready. Proof of this is that at school there were hardly any science materials in the infant part, there was only a shared magnifying glass for the entire cycle since the few science projects that had been developed years ago had been carried out by outside members to the centre as the CSIC. Hence the importance of teacher training since teachers who feel prepared, contribute to open minds and feel capable of reaching new horizons as seen in the work established by Elstgeest (1985).

To conclude, the implementation of this project has served to see that teaching science in classroom is complex but, by performing a correct intervention by the adult, a dialoguing intervention that knows how to select ideas from science and about this, as Harlen (2018) tells us, the students have come to understand that some objects can affect others at a certain distance, for instance, and that it is possible for children to understand and explore science concepts if they are given the right tools. There is still a long way to go as it has been seen since teachers are still not prepared to face the SPS despite the importance that this has to create people with a scientific thinking, capable of facing the problems of the outside world. That is why in this proposal it has been wanted to make a guide of good practices so that through these, teachers can see science as something that can be taught in infant children since through it they will be able to implement proposals as interesting as these of ants or magnetism that are capable of developing SPS .

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ANNEXES

Annex 1. Location of the contents in the curriculum (Ants)

Block 1. Physical environment: elements, relationships and measurement

CC1- The objects and materials present in the environment, their functions and daily uses. Interest in their exploration and attitude of respect and care towards their own and other people's objects.

Block 2. Approach to nature

CC2 - Identification of living beings and inert matter such as the sun, animals, plants, rocks, clouds or rivers. Assessment of its importance for life.

CC3 - Observation of some characteristics, behaviours, functions and changes in living beings. Approach to the life cycle, from birth to death.

CC4 - Curiosity, respect and care towards the elements of the natural environment, especially animals and plants. Interest and taste for relationships with them, rejecting negative actions.

CC5 - Enjoy doing activities in contact with nature. Assessment of its importance for health and well-being.

Cross-sectional contents:

CC6 - Progressive incorporation of appropriate behaviour patterns, willingness to share and to resolve daily conflicts through progressively autonomous dialogue, paying special attention to the balanced relationship between boys and girls.

CC7 - Initiation in the use of technological instruments such as computer, camera or sound and image players.

CC8 - Expression and communication of facts, feelings and emotions, experiences, or fantasies through drawing and plastic productions made with different materials and techniques.

CC9 - Use of the senses: sensations and perceptions.

CC10 - Progressive distinction between reality and audio-visual representation.

CC11 - The family and the school as the first social groups of belonging. Awareness of the need for their existence and functioning through examples of the role they play In your daily life. Appreciation of the affective relationships that are established in them.

Annex 2. Ants activities

Activity 1: What do we know about ants?

- Materials:
    - Sheets of paper, pencil, crayons, digital blackboard, presentation of photos, mural: What do we know?

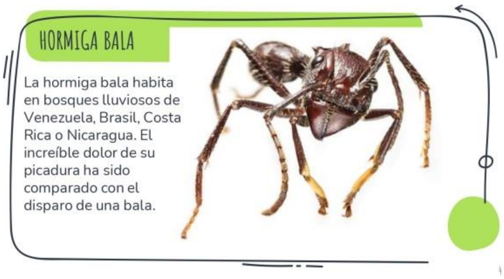
Presentation of photos[7]:

In this first image we see the queen ant, and more ants with the larvae.

Here you can see the difference in sizes more clearly.

We continue seeing the difference in sizes in this case of a soldier ant.

[7] These images have been selected by me based on what I want children to look at specifically, they are randomly selected.



See that there are different types of ants, some sting..

Ants drink

Ants eat, and for this, sometimes they work as a team.

Ants are capable of building nests with very large leaves as they work as a team for this and also are very skilled.

- Objectives:
  - Activate prior knowledge they have about three main elements: classes, food and organization / communication.
  - Develop interest in these three main elements, about the life of ants.
  - Encourage expression and creativity through arts.
- Contents(see Annex 1):
  - CC2
  - CC3
  - CC8
- Skills:
  - Observe
  - Communicate

  Vocabulary: Ant, larva, anthill, gallery, observe, investigate...
- Development:
  - The project on ants is presented to them and they are told to make a drawing of an ant, they are put in groups. To each group some instructions are given according to the group they belong to. Then they are encouraged to draw an ant and then somewhat wider than they know about them.
  - Later in the assembly they will explain the drawing with others and discuss what they think. We can guide them with questions such as: Why have you done it this way? What is that? Why that colour?
  - After that, questions will be asked: what is an ant? Have you seen any? With who? Where?
  - The mural will be completed: What do we know? What do we want to know?
  - Then the presentation of images will be made in which questions will be asked to focus attention and see what they know: What appears in the image? Why are there different kinds of ants? They are dangerous?

Activity 2: Our anthill[8]

- Materials:
  - Digital blackboard, videos (1. Destroyed anthill) https://bit.ly/2ODXYcd ; (2. How to take care of the anthill) https://bit.ly/3tcVgts ; paper, pencil, crayon, ants, set of an artificial anthill, mural.

[8] This activity in the original proposal was intended to be carried out after having gone outside to explore but in this case due to bad weather it has had to be postponed until activity 4.

- Objectives:
  - Activate prior knowledge they have about an anthill.
  - Discover what an anthill is.
  - Know how to take care of an anthill.
- Contents(see Annex 1):
  - CC1
  - CC2
  - CC3
  - CC4
  - CC6
  - CC8
  - CC10

- Skills:
  - Observe
  - Communicate
  - Predict

Vocabulary: ant, soldier ant, queen ant, larva, anthill, gallery, observe, investigate…

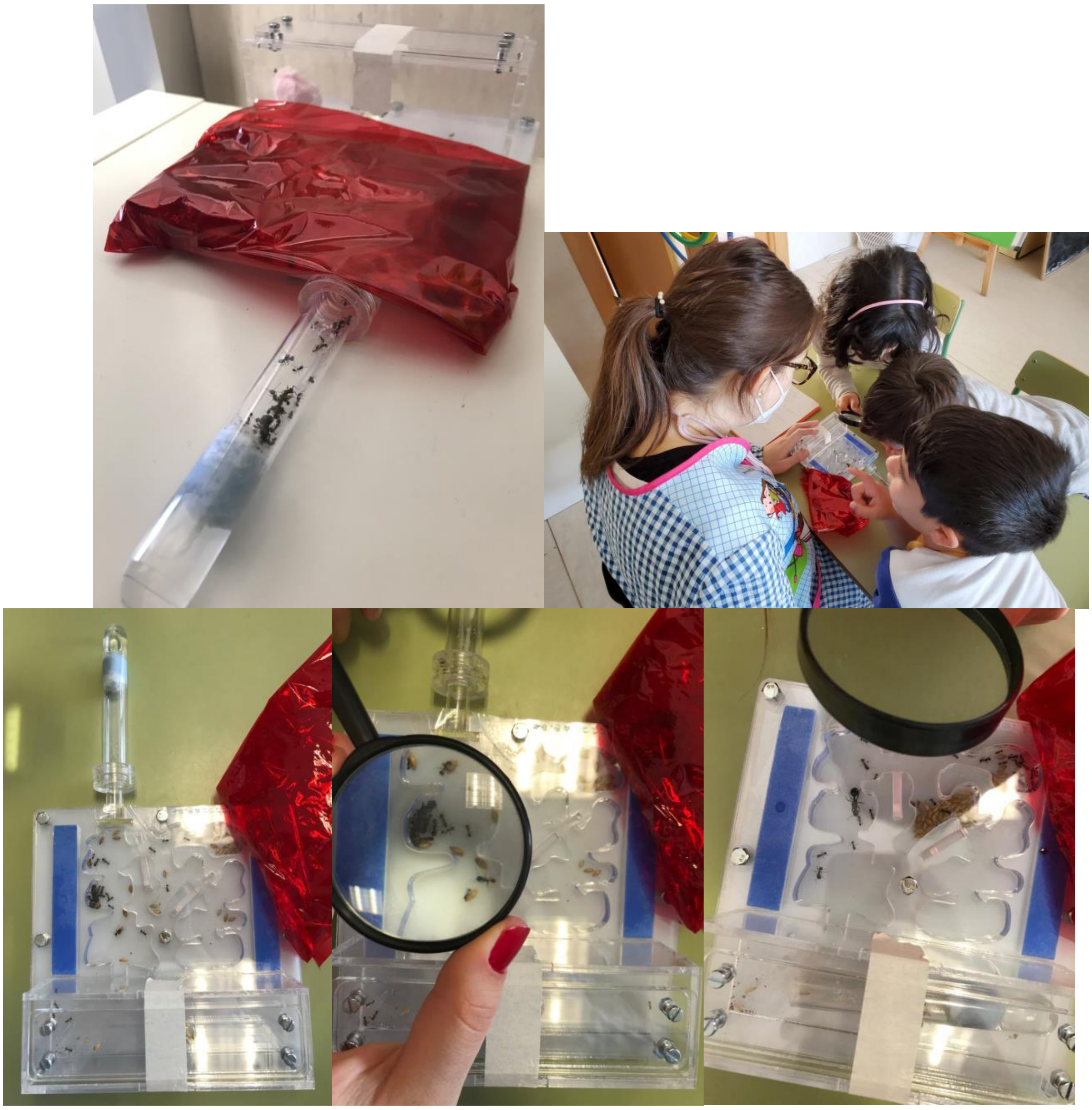
- Development:
  - Draw an anthill in the different groups created. Later in the assembly they will explain the drawing.
  - The teacher of the 3 year old class came saying that she knows that they were working with the ants and believed that they could help her do something. She tells them that this weekend while she was walking with her children, one of them accidentally tripped on an anthill and destroyed it, so ants need a habitat (Video 1 is shown). Then she asks them what they could think or what they could do, insisting that the ants need their help. They will accept the mission. Once they have the anthill, questions of the type ‘’problem-solution’’ are asked: What steps should we follow? What do we put them to drink and eat? Where do we leave them? To give an answer, an explanatory video of the care is played, video 2.

  - After viewing the video, we will recall the steps to follow and decide who is in charge of each of them. Also when we finish, we will collimate our mural to add new things.

Activity 3: Taking care of our ant hill

- Materials:
  - Set of anthill, magnifying glasses.
- Objectives:
  - Know how to take care of an anthill.
  - See the organization of ants, parts of an anthill.
  - Identify and differentiate, in general terms, the organization of a colony.
  - Observe ants.
  - See what happens in our anthill as the days go by, what process follows.
  - Feel proud that they were able to do the caring work.
- Contents(see Annex 1):
  - CC1
  - CC3
  - CC4
  - CC8
  - CC9
  - CC10
- Skills:
  - Observe
  - Infer
  - Interpret data
  - Communicate
  - Measure

  Vocabulary: Jaw, antennas, thorax, articulated legs, observe…
- Development:
  - The different groups are called once a week one by one to observe the changes with the help of magnifying glasses. For this, the three groups of dialogue intervention will be helped with questions such as: Have you seen? Have you figured? Have you noticed? How many? Why do you think? For the imposed intervention they will be told things like: Look, they take the food with the front part, they have clamps like a jaw... and the group that is the listening one will simply be asked to tell what they have observed.



Activity 4: Let`s search for an anthill!

- Materials:
  - Magnifying glasses, necklaces for different groups, sheets of paper, pencil y crayons.
- Objectives:
  - See the organization of ants, parts of an anthill.
  - Identify and differentiate, in general terms, the organization of a colony.
  - Observe ants.
  - Acquire new knowledge and consolidate previous knowledge about ants, organization and communication.
- Contents (see Annex 1):
  - CC1
  - CC2

- CC3
- CC4
- CC5
- CC6
- CC8
- CC9
- CC10

- Skills:
  - Observe
  - Infer
  - Communicate
  - Formulate hypothesis
  - Interpret data
  - Predict

  Vocabulary: Jaw, antennas, anthill, communication, observe…

- Development:
  - In assembly before leaving they are reminded of what a real anthill is like, by projecting photos. In addition, each group is given a magnifying glass.
  - They go to the playground to look for anthills in different parts, each one always with their group.
  - Once they have observed that the ants follow a bidirectional path, they will be asked questions, for beginning the process of inquiry. How can we make them deviate from their path? With the three groups of dialogue intervention ask action questions will be asked to help them make predictions: What will happen if you rub your hand on the path? And if you move the leaf? For the imposed group, the teacher will carry out the action of passing the hand without the previous action questions and for the listening group the teacher will probe question at them, only leaving them to be the ones that direct their exploration. They will be asked why they think that happens, to reach the conclusion that they follow the path through smell, a way of communication.
  - In class, draw what they have seen outside.

<u>Activity 5: What do ants eat?</u>

- Materials:
  - Magnifying glasses, camera, honey, tomato, biscuits and mural.

- Objectives:
  - See the organization of ants, parts of an anthill.
  - Observe ants.
  - Acquire new knowledge and consolidate previous knowledge about ants and their feeding.
  - Get started in the use of the photo camera as an instrument for data collection.
- Contents (see Annex 1):
  - CC1
  - CC2
  - CC3
  - CC4
  - CC5
  - CC6
  - CC7
  - CC9
  - CC10
- Skills:
  - Observe
  - Communicate
  - Classify
  - Predict
  - Infer
  - Formulate hypothesis
  - Interpret data
  - Experiment

  Vocabulary: Larva, jaw, antennas, anthill, observe...
- Development:
  - In the first place in the assembly the teacher will ask what things they think that ants eat.
  - They will go out to the playground to find out what the ants eat, this time group by group. When they are already in the playground teacher will show them three different foods (honey, biscuit and tomato) so that they can make their predictions about which food ants will like the most. They will be allowed (while we let ants time to choose), to explore the garden independently, taking into account the intervention that teacher have decided to make in each of the groups, helping the

groups of dialogue with questions to focus their attention, reason as they have already seen; freely leaving the listening group and directing the exploration of the group of imposed intervention.

- When a reasonable amount of time has passed, they will return to the place where they have previously left the food, to see what has happened (teacher will follow the group intervention method as it is done throughout the project).
- At the end of the session they will complete our mural.

Activity 6: What have we learned?

- Materials:
  - Anthill, pencil, paper.
- Objectives:
  - Revise what we have learned.
  - See the organization of ants, parts of an anthill.
  - Identify and differentiate, in general terms, the organization of a colony.
  - Observe ants.
  - See what happens in our anthill as the days go by, what process follows.
  - Feel proud that they were able to do the caring work.
  - Analyse the predictions made during the outing and compare them with the results obtained after implementation.
  - Make conclusions taking into account the initial explanations, and the comparison of predictions and results.

- Contents (see Annex 1):
  - CC1
  - CC2
  - CC3
  - CC4
  - CC6
  - CC8
  - CC9
  - CC10
- Skills:
  - Observe
  - Infer

- Interpret data
- Communicate
- Measure

Vocabulary: Soldier, queen, jaw, antennas, thorax, articulated legs, observe…

- Development:
  - The different groups are called one by one to observe the changes. For this, the three groups of dialogue intervention will be helped with questions such as: Have you seen? Have you figured? Have you noticed? How many? Why do you think? For the imposed intervention they will be told things like: Look, they take the food with the front part, they have clamps (is a jaw) ... and the group that is the listening one will simply be asked to tell what they have observed.
  - After that, making use of the annotations and recordings that were made throughout the process (in the garden), they will compare the predictions of each small group. To do this, they will revise children's own predictions and compare them to what really happened. In this way, they will be able to check whether their predictions were true or not, based on the results. To do this, teacher will also guide with questions: What happened? Why could that happen and not what you said? …
  - Once they have compared the predictions with the results, they will think about the most important ideas that they have learned with the creation of the anthill, that is, the conclusions, which will also be compared with the initial explanations, and the previous ideas that the boys and girls had. That is to say, these new ideas will replace some of the already existing ideas, or will complement them, in case these previous ideas continue to serve them.
  - These conclusions will also be noted on a mural so that they are visible to everyone and remember them as many times as they want and need. In this way, the inquiry process will be concluded.

Activity 7: Show to our family what we have done

- Materials:
  - Portfolio
- Objectives:
  - Summarize and remember what has been done throughout the project.
  - Show the final product to the families.
  - Feel proud that they were able to do the caring work.
- Contents(see Annex 1):

- CC1
- CC2
- CC4
- CC8
- CC11

- Skills:
  - Interpret data
  - Communicate

Vocabulary: Soldier, queen, jaw, antennas, thorax, articulated legs, anthill…

- Development:
  - With the drawings they have made, a portfolio will be created so that they can take it home and explain what the project has consisted of and what they have learned. In addition it will help them be aware of their evolution in the drawings.

Annex 3. Location of the contents in the curriculum (Magnetism)

Block 1.Physical environment: elements, relationships and measurement:

CC1 - The objects and materials present in the environment, their functions and daily uses. Interest in their exploration and attitude of respect and care towards their own and other people's objects.

CC2 - Perception of attributes and qualities of objects and materials. Interest in the classification of elements and in exploring their qualities and degrees. Contextualized use of first ordinal numbers.

CC3 - Approach to the quantification of collections. Use of counting as an estimation strategy and use of cardinal numbers referred to manageable quantities.

Cross-sectional contents:

CC4 - Progressive incorporation of appropriate behaviour patterns, willingness to share and to resolve daily conflicts through progressively autonomous dialogue, paying special attention to the balanced relationship between boys and girls.

CC5 - Expression and communication of facts, feelings and emotions, experiences, or fantasies through drawing and plastic productions made with different materials and techniques.

CC6 - Use of the senses: sensations and perceptions.

CC7 - The family and the school as the first social groups of belonging. Awareness of the need for their existence and functioning through examples of the role they play in your daily life. Appreciation of the affective relationships that are established in them.

Annex 4: Magnets activities

Activity 1: What do we know about magnets?

- Materials:
  - Salt, iron filings, a piece of magnetite, magnets, stones, video (Magnes the Greek shepherd) https://bit.ly/3a2nqQ4 , mural.
- Objectives:
  - Activate prior knowledge they have about magnets.
  - Develop interest about magnetism.
- Contents (see Annex 3):
  - CC1
  - CC2
  - CC6
- Skills:
  - Observe
  - Communicate
  - Infer
  - Predict

  Vocabulary: magnet, poles, iron, magnetite, attract, repel…
- Development:
  - The project will start by showing that the salt had been mixed with some iron filings and teacher will ask the following question: How can you separate the iron filings from the salt? Teacher will let them make their inferences and test for possible solutions.
  - Teacher will put the Magnes tale on video. When this ends, teacher will ask them what was happening and why did the shepherd stick to that rock. They will again make their inferences.
  - Teacher show them a piece of the same rock that the shepherd stuck to and tell them that it is called magnetite. Teacher also has several stones so that when gluing a magnet to the magnetite they comply and that it only sticks to that one and not to the others.
  - They make some predictions about the objects that the magnet will stick to in the classroom and they are going to check it. To conclude, it is only on metals where it sticks.
  - They will stick the mural on the blackboard with different fridge magnets to point out what they know and what they want to know. To do this, a series of questions are

asked: What is a magnet? How can we know that it is a magnet (it smells, it is heard, it tastes like something)? How does it react when we put close to other objects? Can we make magnets?

Activity 2: What is magnetic?

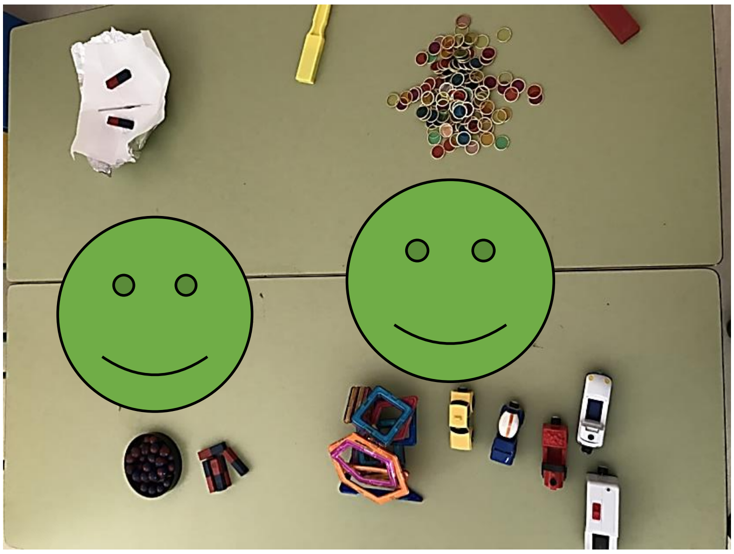
- Materials:
  - 2 boxes, document to classify magnetic and non-magnetic elements.
- Objectives:
  - Realize that we are surrounded by magnetic things.
  - Develop interest about magnetism.
  - Classify and distinguish magnetic objects.
- Contents(see Annex 3):
  - CC1
  - CC2
  - CC5
- Skills:
  - Observe
  - Communicate
  - Infer
  - Predict
  - Classify
  - Interpret data

Vocabulary: magnet, poles, iron, attract, repel, magnetic force…

- Development:
  - Start with listening intervention just telling them to classify magnetic and magnetic objects in the boxes.
  - It goes to a dialogue intervention helping them with a question. What gets stuck? When they gather the material, they will be asked what they have in common, What if..? Why do you think...? What material are they made of..?
  - Finally, the intervention will be guided the teacher tell them what magnetic and non-magnetic objects have found and gives them a card so that they can draw on it the magnetic elements and non-magnetic that they have found in class.

Activity 3: The strength of magnets

- Materials:
  - Knitting needle, magnetic chips, marbles with magnet, train with magnet, magnets...
- Objectives:
  - Discover induced magnetism.
  - See how magnetism is a weak force; it cannot do more than gravity.
- Contents(see Annex 3):
  - CC1
  - CC2
  - CC3
  - CC4
  - CC6



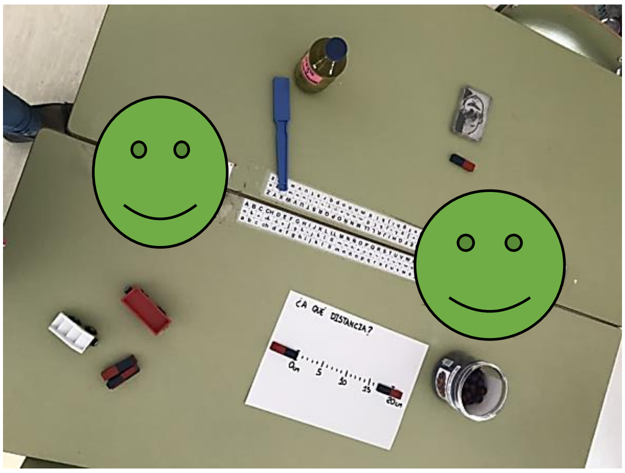
- Skills:
  - Observe
  - Communicate
  - Infer
  - Predict
  - Measure

Vocabulary: magnet, poles, iron, attract, repel, magnetic force, gravity...

- Development:
  - 1st Induced magnetism: with imposed intervention towards listening intervention, passing by dialogue intervention: Have you figured out how many chips you can take?
  - 2nd Magnetism is a weak force, it cannot do more than gravity: From listening intervention to imposed: How many cars, marbles, can you lift together?

Activity 4: The poles

- Materials:
  - Magnets, split magnet, bottle with oil and magnet filings, red and blue stickers, measuring sheet, magnet filings, cardboard.
- Objectives:
  - See how the same poles repel and the different ones attract.
  - Discover how magnets act at a certain distance even if they do not touch.
  - Observe the existence of lines of force entering / leaving the poles.
- Contents(see Annex 3):
  - CC1
  - CC2
  - CC3
  - CC4
  - CC6



- Skills:
  - Observe
  - Communicate
  - Infer
  - Measure
  - Predict

  Vocabulary: magnet fillings, poles, iron, attract, repel, magnetic force lines, potency…
- Development:
  - 1st Same poles repel and the different ones attract: Start with imposed intervention; playing as if they were magnets, for this, different stickers are given for each one (blue or red) so that in this way they join or separate between them depending on the pole. Then they will go on to give them a magnet split in half so that they can check that the colour red and blue have nothing to do with it and they will be set free. Then they will be given a magnet split in half to check that the colour red and blue have nothing to do with the attraction(dialogues intervention) and at the end, will have freedom to explore (listening intervention).
  - 2nd Magnets act at a certain distance even if they do not touch: They are left to explore freely (listening intervention) to see what they tell about the pot with oil and iron filings that is left next to a stick with a magnet. Then (dialogues intervention) some questions will be asked to them: Have you tried? Finally, they will be asked at what distance they think the magnets will join. For this, they will use the sheet with

measurements and the different magnets: Why do you think? What is the difference? For what is this? Until the intervention will be imposed showing it what happened.

- 3rd Lines of force entering / leaving the poles: They are allowed to interact with the filing box with a face drawn to see what comes to mind (listening intervention). The same will be done with the filings that are sprinkled in a container made of paper. They will be asked questions: What if..? Can you find a way to...? (Dialogues intervention). At the end imposed intervention to explain line forces.

Activity 5: What have we learned?

- Materials:
  - Magnetite, split magnet, cars, copper, mural…

- Objectives:
  - Revise what we have learned.
- Contents(see Annex 3):
  - CC1
  - CC2
  - CC3
  - CC4
  - CC6
- Skills:
  - Observe
  - Communicate
  - Measure
  - Classify

  Vocabulary: magnet, poles, iron, attract, repel, magnetic force, copper.
- Development:
  - A review of everything seen and the basic concepts: magnetic force, poles ... They are asked questions to help them to think: What materials attract magnets? What are the ends of the magnets called (where the magnetic force is concentrated)? How many poles does a magnet have? ...

Activity 6: Show to our family what we have done[9]

- Materials:
  - Personal magnet
- Objectives:
  - Summarize and remember what has been done throughout the project.
  - Show the final product to the families.
  - Feel proud of what they have learned.
- Contents(see Annex 3):
  - CC1
  - CC2
  - CC6
  - CC7
- Skills:
  - Interpret data
  - Communicate

  Vocabulary: magnet, poles, iron, attract, repel…
- Development:
  - A personalized student magnet will be created with a photo of each one. That photo will be taken during the process of this project so that they can take it home and explain what the project has consisted of.

[9] Due to the impossibility of going through the other infant classes to show what they have learned, and the impossibility of families to come to school due to COVID issues, this activity has been carried out this way.

Annex 5: Necklace's group

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