The Impact of Teaching Sciences Through Inquiry Based Learning in a CLIL Primary Classroom

El impacto de la enseñanza de las Ciencias a través del aprendizaje basado en la Investigación en un Aula AICLE de Primaria

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Abstract

Throughout this study, the main purpose has been the observation of the impact that the Inquiry-based method has had on my students' conception about science subject. Multiple tasks and activities were implemented to engage critical thinking and problem solving. Towards the end of this study, the experimental group completed a test whose results were compared with those obtained in the initial test. At the same time, a control group with similar abilities were taught based on a traditional methodology. The data was analyzed to find patterns according to these research questions: What are the main difficulties when implementing IBL to teach Science through A Foreign Language? Can IBL change and improve students' conception of science? Can IBL develop the scientific method?

Key words: inquiry-based learning, science teaching, cooperative learning, critical thinking, curiosity.

Resumen

A lo largo de este estudio, el objetivo principal ha sido observar el impacto que ha tenido el método basado en la indagación en el concepto que tienen mis alumnos de las ciencias. Se llevaron a cabo múltiples tareas y actividades para involucrar el pensamiento crítico y la resolución de problemas. Hacia el final de este estudio, el grupo experimental completó un test cuyos datos se compararon con los obtenidos en el test inicial. Al mismo tiempo, se enseñó a un grupo de control con habilidades similares en base a una metodología tradicional. Los datos se analizaron para encontrar patrones de acuerdo con estas preguntas de investigación: ¿Cuáles son las principales dificultades al implementar IBL para enseñar ciencias a través de una lengua extranjera? ¿Puede IBL cambiar y mejorar la concepción de las ciencias de los estudiantes? ¿Puede IBL desarrollar el método científico?

Palabras clave: aprendizaje basado en preguntas, enseñanza de las ciencias, aprendizaje cooperativo, pensamiento crítico, curiosidad.

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1. Introduction

Master classes, problem solving, projects or laboratory tests were the most popular pedagogical methods used in Science instruction. Nevertheless, back in the 1960's, there was movement away from these traditional methods that tried to achieve a higher involvement from the children through the development of thinking skills in the scientific method (Barron & Darling-Hammond, 2008; Perkins, 2009). Although much has been done to improve the methodology of science teaching (Enciende, 2011) in general, little attention has been paid to Inquiry-Based Learning (henceforth IBL) in the teaching of Science through a Foreign Language. In Spain, the current Spanish education law (BOE, 2022, p. 28) reflects that:

> Methodological approaches to teaching Science must start from the students' curiosity to understand the world that surrounds them, favoring active participation in the different processes of inquiry and exploration typical of scientific thought. Therefore, the students must be able to identify and pose small problems; use reliable sources and evidence; obtain, analyze and classify information; generate hypotheses; make predictions; perform checks; and interpret, argue and communicate the results. (My translation)

Over the last few years, the focus has been placed on Content and Language Integrated Learning (CLIL), particularly on identifying effective ways to teach content through a Foreign Language (FL), especially Science (Campanario & Moya, 1999). Learning by doing, thinking skills, active learning, collaborative tasks and the use of language for real purposes are some of the principles that connect the implementation of CLIL and the practical dimension of IBL (Coyle, Hood & Marsh, 2010). The impetus for this study is twofold, firstly the need to involve students in IBL in order to enhance their innate thinking and observation skills as well as their abilities to reflect on the data collected and secondly further investigation is required due to the lack of research on IBL in the teaching of Science through a foreign language.

More specifically, this article tries to address the following three research questions: What are the main difficulties when implementing IBL to teach Science through a FL? Can IBL change and improve students' conception of Science? And can IBL develop students' scientific method? These questions led me to the following hypothesis: Inquiry-based instruction helps Primary students that study Science through a FL to develop a greater understanding of the world that surrounds them since they will be able to acquire the necessary steps needed in research, such as posing questions about their surroundings where they will get answers according to their environment, as well as the capacity to apply this knowledge to the real world.

Following this brief introduction, section 2 will present an overview of the concepts and relevant theoretical issues. Section 3 deals with the data collection process. Section 4 concentrates on the implementation of this method and the different experiments and processes that have been carried out. Finally, section 5 compares the results collected before and after the test that were administered.

2. Theoretical Background

In this section, I will first attempt to define inquiry and explain how IBL works. Secondly, I will review the origins and development of IBL. Finally, I will offer a critical review of the existing literature.

2.1 Inquiry and Inquiry-Based Method

As Couso (2014) points out, the term «inquiry» is surprisingly polysemic in educational literature since this term is more than asking ourselves about what we want to know. According to the Cambridge dictionary, inquiry deals with «the process of asking a question» and is defined as «an official attempt to discover the facts about something». In literature, Short (2009) has defined inquiry as «a collaborative process of connecting to and reaching beyond current understandings to explore tensions significant to learners.» (Short, 2009, p. 12). The most comprehensive definition was put forward by Linn et al. (2004, p. 4) they define inquiry as «an intentional process where problems are identified and analysed, different alternatives are studied, research is planned, models are built, hypothesis is investigated, information is sought and there is debate among colleagues where coherent arguments are constructed».

At present, inquiry is being used as a strategy for teaching and learning science as an alternative to the standardised methods. Following Couso's lines (2014, pp. 3-4), IBL has the following characteristics: (a) It is classified into research environments; (b) The student's role is more active than in traditional learning; (c) Teachers acquire a more passive role; (d) they act as facilitators, there are more sources of knowledge; (e) Attitude and motivation play an important role; (f) Students work in groups, obtain data, ask questions and reach agreements; (g) Students develop their autonomy and decision-making capacity; and (h) Stages are designed in order to simulate scientific methodology.

When IBL is implemented in the classroom, it follows the 5 E's structure (Bybee & Landes, 1990), where each one describes a phase of learning: (1) **Engage**, students identify problems of a scientific nature making connections with their previous knowledge; (2) **Explore**, students actively explore the environment and they can manipulate materials to identify and develop concepts or processes; (3) **Explain**, they verbalize the concepts they have been exploring. Formal terms, definitions, and explanations are introduced by the teachers; (4) **Elaborate**, this is an opportunity to practice skills and behaviors where children develop a deeper understanding of the concepts and get more information about their interests in the area; and (5) **Evaluate**, students assess their own understanding and abilities and the teachers also evaluate students' understanding of key concepts and skill development. In this line of thought, Bybee (1997) states that:

> using this approach, students redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment. Learners interpret objects and phenomena and internalize those interpretations in terms of their current conceptual understanding. (p. 176)

In addition, feedback plays an important role in the students' assessment and should be considered when presenting their explanations. In this process; informal evaluation may be found at the beginning and throughout any of the 5E's sequence. Likewise, a formal evaluation can be completed after the elaboration phase. Learners can be part of this process by asking what the main elements in their learning process have been. Thus, they can elaborate on the rubrics and other types of tools.

The teacher provides a supportive role whose input directly depends on these levels of inquiry. As it can be seen, in open-inquiry children formulate a question to research while in guided-inquiry the teacher must guide the research with the construction of a question (Weaver et al., 2008). The different levels of autonomy discerned by Windschitl (2003, pp. 114-115) are: **Open inquiry:** Students decide what they want to investigate and how to do the inquiry; **Structured inquiry:** The teacher proposes both the inquiry and the method to carry out the investigation; and **Guided inquiry:** The teacher provides the inquiry and the learners choose how to resolve it.

2.2 The History of Inquiry-Based Learning

In the beginning, the term 'inquiry' was used to teach science in the way that scientists practiced it (Dewey, 1910; Schwab, 1960). However, educators are still debating how to measure it in practice (Abrams, Southerland & Silva, 2008; Chinn & Malhotra, 2002). The essence of inquiry has a strong origin in Ancient Greece, more specifically, in Socrates' time (470-399 BC) where we can find that the method of scientific inquiry is not a contemporary concept. The Socratic method created a space where learners and instructors maintained dialogues to promote critical thinking and to seek answers to important questions. In the 13th century, we can find the Latin term inquīrere that means «to seek for». In those days, it was intended to put an end to mysteries, tradition and superstition through direct observation of phenomena. Three centuries later, Renaissance scientists such as Galileo Galilei and Da Vinci relying and expanding on the Socratic method created new technologies such as the microscope and the telescope, thus adding more elements which were needed for the scientific method. During the European Enlightenment in the eighteenth century, this desire to search for scientific knowledge expanded and proliferated (Friesen & Scott, 2013).

The IBL, as it is known nowadays, was started in the 1950's when the space race between the US and the Soviet Union increased the need to develop a more complex Science curriculum. «If a single word had to be chosen to describe the goals of science educators that began in the late 1950s, it would have to be inquiry» (Haury, 1993, p. 4) Likewise, throughout the first half of the Twentieth century, John Dewey, carried out a reform of the educational system that came up with the first IBL methods in the US. According to the National Science Education Standards (National Research Council, 1996, pp. 122 & 145), when children or scientists inquire into the natural world, they ask questions, plan investigations, collect relevant data, organize and analyse collected data. The purpose of this study was to investigate the effects of inquiry-based instruction on third-grade students' attitudes and participation in an elementary science classroom. Students were encouraged to ask and answer their own questions. Moreover, the analysis of instructional practices state that Inquiry-Based reserach used in scientific investigations has been included in the laboratory curriculum of college biology since the 1990's. The use of inquiry-based research increased from less than 10 % to almost 80 % in laboratory classrooms in universities throughout the United States (Sundberg & Armstrong, 1992; Sundberg et al., 2005).

2.3 Review of the Literature

It is conceivable that the implementation of IBL in our classrooms would bring endless advantages. Furthermore, the investigations that have already been carried out in this field are enlightening as the advantages outweigh the disadvantages in terms of academic achievement, students' performance, learning skills and visible results. Regarding to students' academic achievement, as Cohen and Lotan (2014) argued, learners who participate more in lesson discussions get higher scores on standardized examinations. The traditional gaps which emerge in subgroups related to poverty, race or gender differences are significantly decreased when learners have to participate in active learning experiences.

With regard to visible results, a study which was carried out with students at Flinders University reveals that the Inquiry-method had a positive impact on both student outcomes and student satisfaction (Smallhorn et al., 2015). Finally, I would like to conclude this section by highlighting that although IBL is connected with scientific principles, it is a teaching method which can be applied in other areas of knowledge acquisition, to encourage discovery. IBL should be unequivocally used in the educational environment that we are living in today where everything is available at the click of your mouse.

3. Methodology

The main purpose of this research is to understand how IBL affects my students' participation and attitude towards the learning of science through a

Foreign Language. For doing so, qualitative and quantitative methods have been used to collect and analyze data through multiple sources: science attitude test, student portfolio, teacher field notes, and student interviews.

3.1 Research model and the study group

This research was a quasi-experimental study to estimate the causal impact of the Inquiry-method on a classroom without random assignment. The study was carried out with non-equivalent groups, which included pre and post-test design with the control group. The students were divided into two different classrooms two academic years ago by school administration, so it was not feasible to assign students randomly to both experimental and control groups.

The study was conducted with 29 experimental (18 boys and 11 girls) and 27 control group students at 3rd grade in a semi-private school in Madrid, Spain. Thus, the class is composed of a heterogeneous group, with different needs and interests. English Language has been taught since Preschool, so in general terms, the students' English level is good.

3.2 Data collection tools

The Test of Science-Related Attitudes (TOSRA) was completed by the experimental group as pre-test and post-test, the results will explain if there are significant changes in their conceptions about the subject before and after implementing the method. The test was modified and reduced into 20 multiple-choice items, except for two questions that offered the possibility to add comments. In this way, qualitative and quantitative information was compiled to measure the students' interest in Science. The control group only completed the test at the end of the process as their methodology did not change, they studied the information presented in the book and completed the activities proposed in it. In the experimental group, the TOSRA was conducted as a pre-test to collect information about the children's attitudes and feelings towards science and instruction before the implementation of the method. Likewise, at the end of the period of observation, the students completed the TOSRA as a post-test was in order to measure if the previous results were altered or had improved after the implementation of the IBL method at the end of the sixteen weeks. Informal video recorded interviews, student portfolios and field notes were also used to compile data in order to make sure that the scientific method has been properly acquired by the students.

Thirteen qualitative and quantitative questions were asked to different teachers with different backgrounds. The survey could be answered through Microsoft Forms, to collect teacher feedback about this issue. In this way, we can obtain a real appreciation of what happens in Science in my research field. In addition, we can obtain real data on the factors that do not allow the implementation of this method in the classroom.

3.3 Procedures

The study took 16 weeks, from September to January, each week has two 45-minutes sessions. Sometimes it was necessary to take time from other subjects' sessions to carry out the method properly. Two different paths were used in the current study. On the one hand, the control group was taught without changing the methodology; they followed the guidelines established by the book and the contents and the activities proposed on it. On the other, tthe experimental group was taught by using the Inquiry-method and the 5 E's instructional model also field trips and different activities that are explained below.

For setting out the research, it was essential to conduct a survey to access the attitudes and feelings of the students in the experimental group towards science. Learners took a pre and post attitude survey. Due to the age and characteristics of the learners, it was necessary to modify the Test of Science-Related Attitudes (TOSRA) that Dr Barry Fraser developed in 1981. The statements were shortened and reduced to 20, since the original test composed of 70 sentences. The answers were given as emoticons in place of acronyms such as Strongly agree (SA), Agree (A), Not Sure (NS), Disagree (D) or Strongly Disagree (SD) and the negative connotation that each statement showed was changed into affirmative clauses.

Given that personal *interviews* are very useful in establishing through verbal expression what students observe or experience, some children were randomly selected to be interviewed after the implementation of the IBL method. In order to do this, Students' names were written on slips of paper and placed in a box, participants for the interviews were then randomly selected. Questions were modified according to their answers and conversation between teacher and students was used to detect difficulties and complete or clarify previous data. In the same way, the personal interview also allowed me to enquiry further in specific aspects, clarify doubts or complete information (Araque Hontangas, 2011).

Data was collected by means of field notes and student portfolios, where my teaching practices and students' feelings were reflected. These tools helped me to improve my teaching practices in the following sessions. It must be pointed out that part of the qualitative data was collected in the last two questions of the test, and the rest was gathered through the student journals, the teacher field notes, and the interviews.

The topics covered through the implementation of IBL with third graders were: living things (i.e. life processes in animals, humans, plants); plants (i.e. parts of a plant, plant reproduction and nutrition, types of plants); animals (i.e. vertebrates and invertebrates, nutrition and reproduction).

Figure 1

Plants KWL chart in paper format

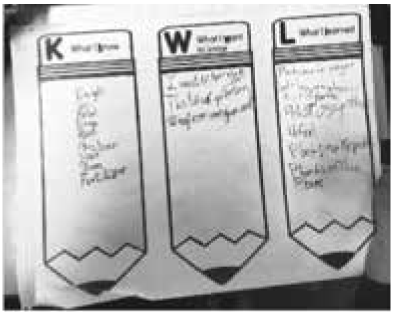
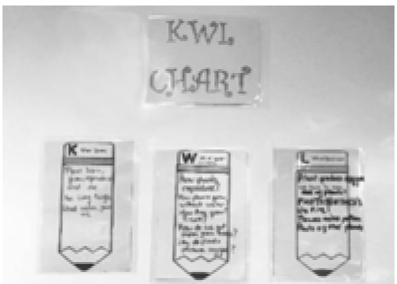


Figure 2

KWL chart on the whiteboard



Different KWL charts (What I Know, What I Wonder, What I Learned) served as graphic organizers that helped the students to organize the information of some topics over a period of time. They had a KWL chart in their notebooks or portfolios and we also shared our thoughts on the one that was displayed on the whiteboard. Through the second phase called exploration, learning environments were created for students where they could observe scientific processes, record data, develop hypotheses, design and plan experiments, interpret results and organize and share their findings.

Different activities were implemented in the hypothesis phase such as experiments where children had to guess what will happen with each one of the different pots, measure the tallest shoot in each pot and count the number of shoots in each one.

Figure 3
Experiments with seeds in five pots with different conditions



In the first picture above, we can see the first shoots sprouting. Nonetheless, mistakes commonly occur in the learning process and were reported in the students' conclusions. Although it may be considered as a very simple process, the children were required to learn how to measure objects for this task.

Figure 4
Picking grapes

Figure 5
Planting lettuces

Figure 6
Taking notes in the field trip

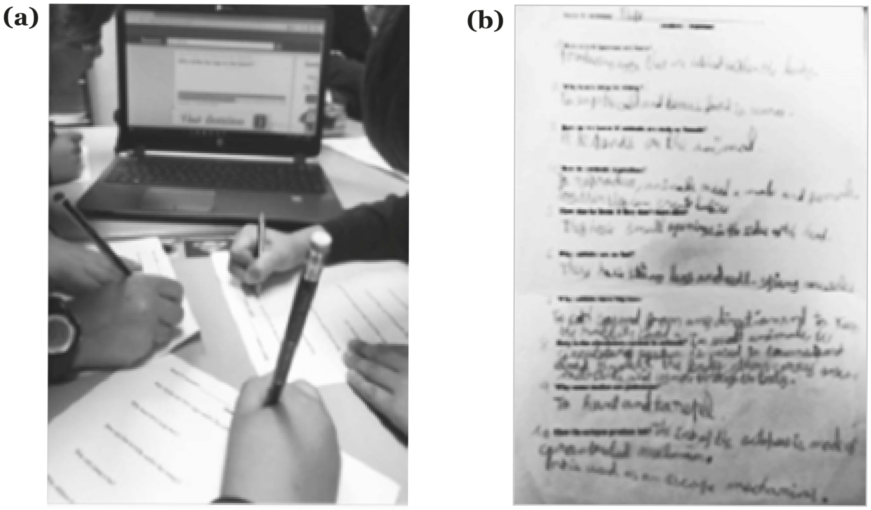
In *figures 6* to *8 (a)*, the children can be seen involved in different activities related to plants. On a field trip, visited a vivarium where the students could pick strawberries, grapes and pumpkins and they planted lettuce and seeds in different soils and pots.

Figure 7

Research corner

Figure 8

Research activity using laptops



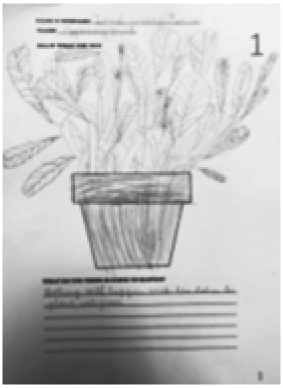
In *figure 8 (b)*, a research corner with magazines and books was set up in the class for finding answers to their questions as well as arousing their curiosity on this topic. Furthermore, they could use laptops with Internet access to find information on the topic. The materials used in the corner were provided by the Science teachers and as such were in Spanish. One drawback that we discovered was that despite the study being conducted in a bilingual school, didactic materials in English were not always readily available.

The activities completed throughout the *explanation* step were intended to help students show their understanding of concepts and to apply their knowledge to new fields.

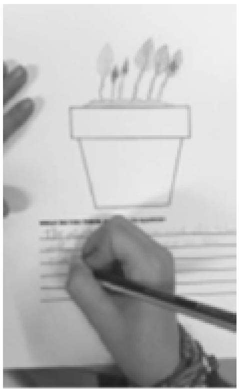
Figure 9

Experiment about photosynthesis and deciduous plants

(a)



(b)



(c)

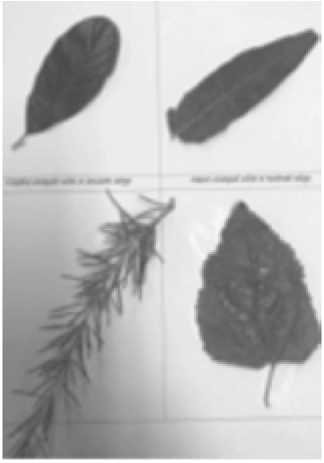
In *figures 9 (c)* to *10 (b)*, the children draw what they see and then hypothesize about what will happen in the next few weeks. Three black stars were placed on three leaves of the plant preventing the sunlight from being absorbed by the plant in these parts. The children served that this causes the leaves turn yellow, because sunlight is necessary for plants to carry out photosynthesis.

Figure 10

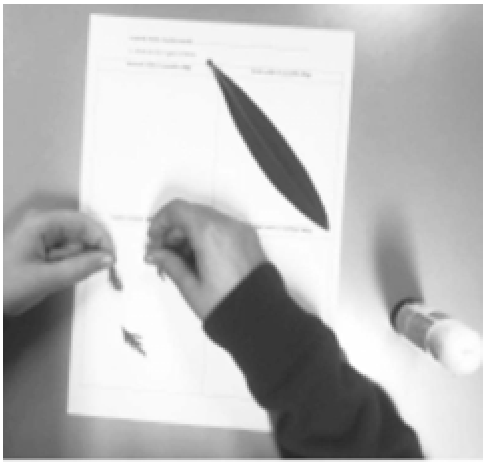
Experiment about photosynthesis and deciduous plants

(a)

(b)



(c)



In *figure 10*, the students can be seen looking for different types of leaves in the school area in order to classify them. Therefore, we could also see the difference between deciduous and evergreen trees. Once we collected the leaves, we established the types and added some more types.

The activities that were carried out in the evaluation phase meant that learners could assess their understanding and newly acquired skills. These activities were also used by the instructor for both formative and summative evaluations of the students' learning process.

Finally, in the rubric activity I want my learners to be involved in the process of creating the assessment for the unit. We created the main headings and we developed the different ways in which we can answer different questions, letting them know the different punctuation in each one of the cases.

4. Analysis and results

This study was carried out throughout the first term and it aimed to address how inquiry-based instruction influenced children' participation and their attitudes towards science. The primary mode of investigation was based on action research with my current students.

4.1 Difficulties when implementing inquiry- based learning method

The first research question features the difficulties that this method may present through its implementation. These will be analyzed by asking teachers' opinions about this issue. This study discovers that there is an obvious tension between their understanding of ideal method to teach Science and the challenges involved in implementing IBL in the classroom. The survey was filled out by 38 teachers from both Primary and Secondary levels, although this study is focused on Primary, it was considered important to observe whether this method was known by teachers from other educational stages. The conclusions of this survey must be taken as a pilot study and in order to generalize it, the sample should be expanded in future studies, this should be taken as a starting point for future investigations in this field. As it has been previously noted, the limitations involving human resources and sufficient time, meant that decisions had to be made to work based on the data available. For all these reasons, these can be the foundations for future investigations.

From the 38 teachers surveyed, 39.5 % work in State schools, which represents more than half of them, 55.3 % work in semi state schools while only 5.2 % of the respondents work in private schools. Additionally, 73.7 % of the teachers surveyed work in primary education, 8.5 % in secondary education, and 7.8 % in preschool. Of these 38 teachers, 71.05 % of them have taught Science at some point in their lives. The remaining 28.95 % have never taught Science. Another factor which is important to take into account is the language in which Science is taught in their schools. In 81.6 % of the interviewees' schools Science is taught through English, on the other hand, only 18.4 % of the schools continue to use the mother tongue, Spanish, as the teaching medium for the subject. Regarding what the curriculum states about teaching Science in Spain, 71.05 % of the interviewees affirm that they are aware of these guidelines. However, only 57.9 % affirm categorically that this method is implemented in their classrooms. An example of a typical answer would be: «Yes, I strongly believe that science should be learned this way and I always try to promote inquiry, creative and critical thinking, cooperative work, investigation, etc.».

Another interviewee made the following comment: «Definitely, we use collaborative methods, project-based learning, open ended questions, and students are encouraged to think for themselves. We rarely use the text book». It is important to highlight that the textbook could be considered the antithesis of this method since the information is already given, the knowledge that students must assimilate is already written, instead of the students making decisions about what they want to know or discover. By contrast, 26.3 % of the teachers who completed the survey, affirmed categorically that they do not carry out this method:

> Not as much as I would like to because even though the school likes this methodology, students have a textbook, which needs to be followed. I understand that the book is not the only tool available and should be just a guide, but with only 45 minutes it is difficult to apply this methodology and complete the book.

At this point, we can observe some of the drawbacks that professionals encounter in their daily teaching practices. 15.8 % are insecure about the implementation of the method «It's difficult to practice it in the two sessions we have a week while also teaching the rest of the curriculum which is tested in the state exams. Besides, the previous quite? is not related to the rest of the content». Despite the fact that the answer should be «yes» or «no», many of them communicated their discomfort with some aspects that govern our teaching subject and what little can be done about aspects such as the State exams.

Another important aspect that should be investigated is how much awareness there is of this method, a method that goes beyond doing research or laboratory practices in a timely manner, amongst the teaching professionals. Of the 47.36 % of professionals who claim to have heard of this method, the most curious thing to note is where they knew of it from: From a bachelor's degree, thanks to an English publisher of my school (Oxford), reading on the internet, their own research, from professional training devoted to broadening teacher skills and competences, because of my experience as a researcher, in a teaching course, in pedagogic innovation courses. Only 5 of them, which means 13.15 % of the surveyed, affirmed that they learnt about the method thanks to some subjects in university. It seems striking, that something that our curriculum demands, while not specifically under the name of IBL, is not taught in basic teachers training and that it is the teachers themselves who have, of their own volition, have learnt about this methodology.

Following the previous question, when they were asked if they would like to put IBL into practice in their classrooms, only one of them answered «no» because of the students' age. Of the teachers questioned, 86.84 % of them argued that this method sounds very good considering the following statements: «I think this is the way students should learn science. This way, they will really enjoy it and will feel motivated and responsible for their own learning» and «children should learn Science taking into account their innate way in which they know the world, by asking questions». Others reflected that «It improves their scientific competence» and «as it is a methodology in which students are able to think, reflect and wonder about the world. From my point of view, something that is experimented by themselves, is worthy and easier to recall in a future». Whether or not they put this methodology into practice, the survey fulfilled a function, which was to make this method known to those who had not heard of it. It seems that with some answers, the basis on which this method is founded has been established; logical and critical reasoning, a respect for the way in which children learn, reinforcing and encouraging their critical spirit, giving them the opportunity to learn what they really want by establishing minimums or guiding the knowledge acquisition, etc.

To conclude this section, it is important to highlight the problems that teachers believe that this method can present through its implementation. In the following table, four possible drawbacks were presented, and they had to choose their level of agreement; being 1 fully disagree and 5 strongly agree:

Table 1

Results of the survey implementing inquiry-based learning method

Inquiry-based method may be time-consuming Mean = 3.58				
1 Fully disagree	2 Disagree	3 Not sure	4 Agree	5 Strongly agree
2	2	13	14	7
5.26 %	5.26 %	34.21 %	36.84 %	18.42 %

Money: school should provide me a quantity of money for buying materials for the experiments. Mean = 3.32				
1 Fully disagree	2 Disagree	3 Not sure	4 Agree	5 Strongly agree
4	7	8	11	8
10.52 %	18.42 %	21.05 %	28.94 %	21.05 %
Academic formation: I've never been taught how the scientific method works. Mean = 2.97				
1 Fully disagree	2 Disagree	3 Not sure	4 Agree	5 Strongly agree
10	4	7	11	6
26.31 %	10.52 %	18.42 %	28.94 %	15.78 %
Knowledge: I'm not sure of my knowledge in the field of science. Mean = 2.26				
1 Fully disagree	2 Disagree	3 Not sure	4 Agree	5 Strongly agree
13	10	8	6	1
34.21 %	26.31 %	21.05 %	15.78 %	2.63 %

To start with, most of the teachers agreed that this method may be time-consuming. It is evident that this method takes more time than direct instruction, since we start from the students' previous knowledge and it is them, with the help of the teacher as facilitator, who guide the course to new knowledge. Secondly, it is obvious that some experiments need different materials that not all schools can provide. Based on my own experience, the majority of materials were provided by the school, but other materials such as plants, soil, cotton, sand, seeds, and glasses were provided by me. We require the schools' assistance to implement this methodology. However, the costs that may be involved should not be an impediment to the proper functioning of the activities. In my case, I preferred to oversee the materials I needed because I knew where I could find them in a faster way. Preparing them with enough time, it should not be an impediment to school. According to the data obtained, we could assume that money required for carrying out the different activities through IBL does not imply a drawback.

Approximately half of the teachers know how the scientific method works. At this point, we must take into account that if half of the professors surveyed do not know what the scientific method consists of, we can conclude that they will not know how to transmit it to their students, and even less how to work with learners in this way. Despite the fact that half of the participants showed confidence in this area of scientific knowledge, the rest of the teachers did not feel confident about teaching sciences. Of the teachers who responded that they did not feel confident about teaching the methodology, only two were secondary teachers. Thirteen of the participants (34.21 %) agreed that their knowledge was not good enough to teach this subject. Furthermore, these are currently teaching in primary and pre-school stages, which means that they should have taken subjects in university where they had to deal with teaching Sciences. Although it is a small sample of respondents, I consider it a revealing fact in which until a few months ago, I saw myself reflected. Finally, a space to add other inconveniences of the method was added so that the respondents freely wrote their opinions about it. Five of them revealed that there were no other things that would stop them carrying out this method «I don't think there are factors that would stop me when carrying out Inquiry-based method since I think is the best one».

Regarding time limitations, seven of them repeated that it is an important factor to take into account when applying this method «Time! We have to see so many concepts that it's quite difficult to see them all through experiments or action-reaction processes» another explained:

> The lessons are very short (45 minutes). There is too much content to teach them in a short period of time. Some experiments take too much time to be prepared and with large classes it could be difficult to carry them out, especially if there are disruptive students. In addition, it sometimes requires time for the teacher (previous information, how to prepare the activity, organize students, etc.).

Some of them mentioned areas for concern might be, their English level, the number of learners in the classroom, their knowledge or behaviour: «The number of students in a classroom, sometimes the number is high and this makes the work and the ability to follow them individually more difficult», «Conducting research with teenagers is challenging because every class has its own features and plans don't always work as expected. Students' bad behaviour and lack of interest may definitely affect your data and thereby your results». «How students show their knowledge. The way to express the contents in English».

The teacher staff was mentioned by three of the teachers questioned, as one of the possible reasons why this method could present difficulties; «the teachers that also work in my school, for them it is easier to read the book and do the activities rather than preparing these lessons». It is an interesting point of view especially as this is a time-demanding method that needs to be put into practice in the following years, otherwise, all these skills that need to be continuously updated will be forgotten. Furthermore, three other teachers agreed on the idea that they would need specific training in order to apply this method; «The non-supervision of experts in IBL while I am developing this methodology» or «Universities should have a specific program about teaching science through this method». As far as I am concerned, I fully agree with the following statement «If we do not eliminate text books. Their use promotes factual learning and memorisation over investigation». As they work as a guide that has to be followed, the teachers and students will be unable to develop further research when the knowledge that they should know is already taken for granted.

4.2 Changes and improvements on students' conception of science

A research project was designed to assess the impact of Inquiry-based learning on primary students' conception of Science. Through multiple sources of data, the second research question was addressed. The Test of Science Related Attitudes (henceforth TOSRA) was the main tool used in the study. This survey was administered as a pre and post-test at the beginning and four months after the implementation of the method. Likewise, student journals, audio recordings, and student interviews were essential to uncover other aspects of this study. The second research question was posed to analyze the quantitative and qualitative data obtained by TOSRA, and verify whether or not there was a positive impact on the students' attitudes towards IBL by comparing the results gotten before and 16 weeks after its implementation in the classroom.

The analysis of the data will be divided into two parts, the first one will deal with questions that are related to science in general terms and the subject of Science; such as the importance of fostering curiosity through this method and letting students see the impact and benefits that Science has in the real world, their reactions and feelings about this subject in the school, and comparing Science with other subjects. The second one is directly related to the implementation of IBL; their attitudes and skills when developing the scientific method, and their conceptions about Science subject and the method.

To start with, the first section provides evidence about the importance of fostering curiosity and discovery-based learning in all areas and specifically in science. Curiosity and exploration are two interrelated concepts that are commonly linked to motivational constructs like motives, drives, intrinsic motivation, etc. (Voss & Keller, 1983).

Table 2

TOSRA TEST RESULTS: The importance of curiosity in learning stages

	SA	A	NS	D	SD
1. I am curious about the world in which we live					
Experimental – Pre-test	64.3 %	17.85 %	17.85 %	0 %	0 %
Experimental – Post-test	51.72 %	34.48 %	13.79 %	0 %	0 %
Control	64 %	16 %	20 %	0 %	0 %
2. Finding out about new things is important					
Experimental – Pre-test	57.15 %	35.7 %	0 %	7.15 %	0 %
Experimental – Post-test	82.75 %	13.79 %	3.44 %	0 %	0 %
Control	64 %	12 %	12 %	12 %	0 %

As far as curiosity is concerned, similar results were gotten in the experimental and control group. As it has been shown previously, children show an intrinsic curiosity as a way in which they can learn about the world. However, the question that deals with the importance of finding out about new things, an improvement is relevant. In the experimental group an increase of 25,6 % was noticed. This is relevant as far as the scientific method was worked. Learners could see the importance of announcing new discoveries in different fields and how important they are in terms of evolution. At the beginning of the school year, children did not seem to be motivated with Sciences due to the previous years they learned contents studying them directly from their books instead of exploring them. This issue was taken as a starting point to implement this method with the objective of relating what is done in the classroom with the real world.

Table 3

TOSRA TEST RESULTS:
Impact and benefits of Sciences in real life

	SA	A	NS	D	SD
3. Science helps to make life better (medicine, discoveries, etc.)					
Experimental – Pre-test	46.42 %	32.14 %	17.85 %	3.57 %	0 %
Experimental – Post-test	65.51 %	17.24 %	17.24 %	0 %	0 %
Control	76 %	20 %	4 %	0 %	0 %

In the light of the previous argument, connecting the contents to the real world has been a key element in the guiding thread of the sessions. Learners always demand a real purpose of the contents that they are learning. In this aspect, table 3 represents the results of their thoughts in this field, letting them realize about the real purpose of the experiments, the importance of discoveries and the need to repeat tests to make sure of the progress we made. Children in the experimental group, could be more aware about this aspect at the end of this study. Surprisingly, the results of the control group show that these children are more aware about this aspect. This could be happened because students often can reach these conclusions from other approaches. Nevertheless, the importance lies in the fact that students get reasons to realize that the contents that they study are significant for the world in which we live. Natural science subject has been the area of knowledge used to implement the method, so asking learners in different ways what are their feelings about this subject has been a key element in this study.

Table 4

TOSRA TEST RESULTS: Reactions about Science lessons

	SA	A	NS	D	SD
5. I would enjoy school if there were no science lessons.					
Experimental – Pre-test	10.71 %	10.71 %	7.15 %	17.85 %	53.57 %
Experimental – Post-test	3.44 %	0 %	6.89 %	13.79 %	75.86 %
Control	44 %	0 %	8 %	8 %	40 %

This table illustrates significant differences in the results gotten in the pre and post-test by the experimental group in terms of enjoying or not Science lessons. What is relevant is the fact that the percentage of students that did not enjoy Science at the beginning of the course has decreased. By contrast, the percentage of students that enjoyed the subject increased in 22.29 %. In the control group, learners studied similar contents by following a more traditional method. However, the results were extremely striking since the students have a very divided opinion that tends to extremes; 44 % of the students do not enjoy science subject, while 40 % of the class thinks otherwise. These data show that IBL is a good method to let students learn in a more relaxed atmosphere, where they enjoy the lessons.

Table 5

TOSRA TEST RESULTS: Comparing Science lessons with others

	SA	A	NS	D	SD
7. Science is one of the most interesting school subjects.					
Experimental – Pre-test	28.57 %	14.28 %	39.28 %	10.71 %	7.15 %
Experimental – Post-test	48.27 %	34.48 %	13.79 %	3.44 %	0 %
Control	36 %	8 %	28 %	8 %	20 %

This table shows a certain improvement when we compare Science subject with the rest. At first, only a quarter of the class thought that it was the best subject, but in the end, more than the half of the class shared the same thought. On the contrary, control group showed very divided opinions; 36 % of them though that it was one of the most interesting subjects, and 20 % though the opposite, having a 28 % of the students that were not sure about this issue. One of the reasons why it can happen is because the traditional method does not make the same impact on the students in the same way.

Table 6

TOSRA TEST RESULTS: Looking forward Science lessons

	SA	A	NS	D	SD
8. I look forward to science lessons.					
Experimental – Pre-test	39.28 %	28.57 %	21.42 %	7.15 %	3.57 %
Experimental – Post-test	44.82 %	37.93 %	17,24 %	0 %	0 %
Control	32 %	20 %	0 %	16 %	32 %

In this case, the students were asked about their desire for having Science sessions. The results improved in the post-test to such an extent that no student thinks otherwise; considering the answers of Strongly Agree and Agree, an improvement of 14.9 % was noticed. Newly, the results of the opinions in the control group were very distributed along the possible answers, showing that they were sure of them because no one answered not being sure. Having all these previous results into account, the second section will deal with the impact that IBL and the scientific method have had in students' conception about Science subject, that is the real nature of this research. Throughout the following table, different data that deals with teamwork, repeating experiments, using new methods and reporting expected and unexpected results, will be shown.

Table 7

TOSRA TEST RESULTS:
Attitudes and skills when developing the Scientific method

	SA	A	NS	D	SD
9. When I work in groups, I like to listen to people whose opinions are different from mine.					
Experimental – Pre-test	32.14 %	10.71 %	28.57 %	14.28 %	14.28 %
Experimental – Post-test	62.06 %	10.34 %	20.68 %	3.44 %	3.44 %
Control	52 %	16 %	8 %	8 %	20 %
12. I like repeating experiments to check that I get the same results.					
Experimental – Pre-test	25 %	17.85 %	28.57 %	14.28 %	14.28 %
Experimental – Post-test	58.62 %	3,44 %	34.48 %	0 %	3.44 %
Control	68 %	4 %	4 %	8 %	16 %
13. In science experiments, I like to use new methods which I have not used before.					
Experimental – Pre-test	57.14 %	25 %	10.71 %	3.57 %	3.57 %
Experimental – Post-test	72.41 %	3.44 %	17.24 %	3.44 %	3.44 %
Control	56 %	16 %	20 %	0 %	8 %
14. In science experiments, I report unexpected results as well as expected ones.					
Experimental – Pre-test	14.28 %	7.15 %	39.28 %	10.71 %	28.57 %
Experimental – Post-test	58.62 %	13.79 %	24.13 %	0 %	3.44 %
Control	40 %	4 %	16 %	4 %	36 %

This last part of the TOSRA tries to give an answer to questions that are related to the development of the scientific method. Active listening has been an essential element throughout this process. The first question of table 7 presents that this skill has been worked since the beginning, as the 62.06 of the experimental group, 74.4 % of them if we also take into account those that answered agree, liked to debate and listened to others that had different opinions. At the beginning of the implementation, they only were focused on their own results. However, within the days they were able to appreciate this fact as they could learn from other points of view. It was also fascinating, listening to them when they shared their data and conclusions as the way they expressed themselves improved and their vocabulary became richer.

As some experiments were carried out, students could not understand the importance of repeating them. It was hard to let them realize that the more times an experiment is repeated, the more reliable the data will be. For some groups this task was simple, since they gathered a good collection of data and they made sure that the experiments worked well. However, it was demotivating for those groups that did not get conclusive data. For this reason, different debates were held, so all the groups could reach the same conclusions. Returning to the results obtained by the test, we can see that the percentage of students who liked to repeat the experiments increased by more than 25 % in the experimental group. On the contrary, this question is not meaningful for the students of the control group since they have not performed any experiments.

Using new methods provide students different ways to achieve knowledge. In this sense, new approaches were facilitated for developing the experiments. Children could benefit from this aspect and saw its usefulness as almost three-quarters of the class agreed on enjoying using new methods. Once again, the results in the control group cannot be contextualized as they did not perform anything related to the scientific method.

When carrying out experiments, hypothesis is the fundamental pillar of this approach. Furthermore, it is very beneficial for children when they discover different results than the expected ones, and the importance of reporting them. As the last question exposes, at the beginning of the academic year only 14.28 % of the students in the experimental group could realize about this issue. Fortunately, at the end, an improvement of the 44.34 % was noticed. This result means that learners appreciate everything that takes place during the process.

In all the results of the collected data, an improvement was shown in the experimental group after the method was started up. In contrast, the control group showed a lower performance in all these aspects since, although they carried out a cooperative work methodology, they did not carry out any activity presented in the scientific method. At this point, it is also important to make a brief reflection about the need of supporting at home what students work and create in the school. That is why it has been decided to analyse the data if they wish to continue performing these experiments at home.

Table 8

TOSRA TEST RESULTS: Extrapolate the subject to their homes

16. I would like to do science experiments at home.					
Experimental – Pre-test	53.57 %	17.85 %	10.71 %	3.57 %	14.28 %
Experimental – Post-test	68.96 %	3.44 %	13.79 %	10.34 %	3.44 %
Control	80 %	4 %	8 %	0 %	8 %

When conducting experiments at home, this table reveals that there is a slight improvement in the results obtained in the post-test of the experimental group, from 53.57 % to 68.96 %. At this point, it is curious how the control group showed more enthusiasm, as the 80 % of the students agreed on this issue. It is true that the students in the control group were a bit discontented to see that the experimental group was doing more dynamic and meaningful activities than theirs.

Table 9

TOSRA TEST RESULTS: Conceptions about Science and IBL

19. Science lessons are:		Lots of fun	Boring
Experimental – Pre-test		50 %	50 %
Experimental – Post-test		96.55 %	3.44 %
Control		60 %	36 %
20. Doing experiments is	As good as finding out information from teachers.	Better than reading about them.	Worse than learning things from the book.
Experimental – Pre-test	53.57 %	35.71 %	10.71 %
Experimental – Post-test	17.24 %	79.31 %	3.44 %
Control	52 %	44 %	4 %

On the one hand, the students' opinion at the beginning of the academic year was really divided in the experimental group, as half of the class thought that Science subject was boring in contraposition of the other half of the class that thought that it was lots of fun. At the end of these four months, their conception regarding the science subject improved more than considerably in the experimental group, from 50 % to 96.55 %. and in the end, everyone thought that the classes were fun except for one student. Some of their reflections were the following ones: «because we do experiments, we discover new things, we draw mind maps and excursions», «I like science because we make experiments, we have fun and we play games».

The last question of the test had three possible options where learners had to choose the one that most reflect their thoughts when carrying out experiments. In the experimental group, most of the children thought that it was better than reading about them (79.31 %) proof of this, are some of the observations that left reflected in the test; «making experiments is better because we discover things by ourselves» other reflected «I like doing experiments more than reading because when we read we do not do anything fun, when we do experiments we discover things».

4.3 Students' interviews

After the interviews took place, I could realize how important this tool was as students were willing to answer all kinds of questions. They felt somehow important to be heard and it let me collect data that until that moment had not been reflected on the tests or in their notebooks. Eighteen parents authorized me to interview their children, but I could only do it with six children that were randomly selected through the method previously explained in Procedures section (3.3). The interviews were administered with audio recording and they could choose the language in which they felt more comfortable; five of them preferred to do in Spanish and only one in English.

In general terms, the implication of families and students in this school could be seen as very positive due to they are willing to take part in new methodologies. Taking this into account, eighteen families authorized me to carry out these interviews, that were handled within three days. However, having had more time, I could have interviewed all of them. The interview consisted of eight questions that were carefully chosen with the intention of exploring how the scientific method was worked and if they felt a real connection with it. The questions suffered minor variations according to the answers they were giving. Once the interviews were recorded it was observed whether or not they had problems when answering them.

The audiotapes transcripts presented that the interviewed appeared to be pleased with the inquiry experience. After analyzing the transcriptions, it could be appreciated in the moment they were asked about how they felt about doing experiments, they used optimist expressions to expose their feelings. Some of the student´s answers were: «I feel very good, I feel as a real scientist». We may assume that these tasks are meaningful to them and are contextualized as they have been given the opportunity to put themselves in the scientists' shoes. Throughout the questions, they could reflect on some steps that were carried out when developing different tasks. Although the scientist method has not been taught in detail, with its steps and procedures, children have been able to extract the most important ones from the activities that have been done inside and outside the classroom; «analyzing and comparing the data, observing what happens during the process, we have to measure all the things that we have to measure, to agree on something, analyze things, observe something that happens in the nature» All of these aspects are related to each part of the 5E learning cycle.

Another critical issue in the interviews was the importance of working in groups and sharing the results we get throughout the implementation of IBL in my classroom. New opportunities to work in groups have been increasing progressively since September through collaborative research and projects. Some reflections in the interviews let us suppose that they are able to see a benefit to group work «you don´t know if other people got the same result as well» and «other people deserve to know it and if they are wrong so… can we correct it all together». They felt the need to compare the results and their hypothesis in order to see whether or not they were right, and they also realized about the importance of letting people know the advances they were doing. These students' reactions to inquiry-based experiences produced an increasing in participation and developed positive attitudes since the beginning of the study.

5. Conclusion

Throughout this study, the main purpose has been the observation of the impact that the Inquiry-based method has had on my students' conception. Over this period of sixteen weeks, different tools of data collection have been taken into account in order to establish some conclusions. In September, 29 learners in the experimental group were brought into the study by filling out the TOSRA pre-science attitude test. In the following weeks, different tasks and activities were carried out in order to engage critical thinking and problem solving through posing questions, some of them by the children and others by the teacher. Towards the end of this study, a post-test was administered with the intention of comparing the results obtained from the pre-test. At the same time, a group of 27 students with similar abilities were designated as the control group who were taught based on a traditional methodology. This control group also performed the TOSRA test. The data was then analyzed to find patterns according to the research questions.

What are the main difficulties when implementing IBL to teach Science through A Foreign Language? A survey completed by 38 teachers working in different educational environments, was the main tool that showed teachers' perceptions of scientific inquiry. This study discovered an obvious tension between what our National curriculum states as its objectives for Science teaching and what the main difficulties that teachers encounter when they have to implement these objectives in the classrooms. The answers imply that these are the main factors that hinder the implementation of IBL in our schools: this method may be time-consuming (3.58), it also requires an investment in materials by the school (3.32), teachers demand specific instruction throughout their training (2.97) and this impacts on their knowledge, as they are not sure how this method really works (2.26). Some measures to implement this scientific method in our schools would begin by including a specific curriculum in the universities, increase the time provided for teaching in this area in schools, and the necessary means for putting into practice this method should be provided by the schools.

Can IBL change and improve students' conception of Science? These findings suggest that the implementation of IBL in Science lessons has had a measurable impact on both student participation and satisfaction. This indicates that the shift to inquiry-based learning has improved the learning outcomes. In contrast to what was observed of the control group, since they continued to be immersed in a more traditional method. In the light of these results, there is a significant difference between the achievement levels of the students who have taken part in the IBL supported by the 5E learning cycle (the experimental group) and the students who have been taught following the baselines of the traditional teaching methods (the control group). Their motivational levels are completely different as well as their level of participation, something that directly impacts on their levels of achievement. These findings also highlight the importance of incorporating student-centered methodologies in the lesson planning by providing them with opportunities to formulate and explore questions through their immediate environment.

Can IBL develop the scientific method? Thanks to the implementation of different activities throughout the weeks of this study, it has been observed how children developed their scientific skills in different situations. Although the steps of the scientific method have not been taught theoretically, the students have been able to extract the most important steps since they have applied them in practice. It was observable, through the data analyzed in the interviews, that this was the result of the improvement of their attitudes as well as their motivation to take part more in different lessons, resulting in the improvement of their ability to observe their immediate environment and pose questions.

Finally, some of the limitations of these outcomes may include the IBL method only being implemented in the Natural Sciences subject from one third grade classroom. Secondly, it was agreed that at the beginning both groups (experimental and control) were going to be taught according to the Inquiry-based learning method. However, the other teacher preferred to follow the book as the main resource of the subject due to the amount of time needed to carry it out properly. That is why; the group of 27 children were taken as the control group. Moreover, the TOSRA test was modified and shortened by the researcher and it was focused on the areas considered significant to the study.

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