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The Teaching of the Experimental Sciences in Primary Education through a Methodology by Inquiry: Learning Difficulties and Pedagogical Guidelines

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ABSTRACT

This paper aims to analyze the importance of the acquisition of scientific capacities in primary education within the framework of the key competences highlighting the contribution of this to the development of the scientific culture of society hence the importance of aspects that are to be dealt with in this paper. After carrying out a review of the main difficulties for the understanding of the curricular contents included in the area of the experimental sciences we will focus on the methodology by inquiry as a proposal of work in the classroom to finish with a series of pedagogical guidelines to have in that they facilitate the teaching and learning process of the experimental sciences in primary education.

KEYWORDS
Scientific literacy; Experimental sciences; Primary education; Key competences; methodology by inquiry; pedagogical guidelines; scientific culture

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Introduction

The incorporation of the Area of Experimental Sciences into the curriculum of Primary Education is essential to bring students to the natural world that surrounds us, understand it and become involved in its care and conservation. Through this area, they begin to develop the main strategies of scientific methodology, such as the ability to formulate questions, identify the problem, formulate hypotheses, plan and carry out activities, observe, collect and organize relevant information, systematize and analyze the results, draw conclusions and communicate them, working cooperatively and making appropriate use of materials and tools.

However, there are many difficulties surrounding learning in the natural sciences. Among them, we can cite the lack of motivation on the part of the

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students due to diverse causes like the implementation of traditional methodologies. On the other hand, it is also necessary to emphasize the inadequate understanding of the nature of scientific knowledge and that must be a necessary requisite in the training of science teachers.

In the present article, we analyze the importance of scientific competence as well as the errors at didactic level that surround the teaching and learning process of the natural sciences in the primary stage. This will be our starting point to finalize with the elaboration of a normative section based on a series of pedagogical guidelines that we consider essential in the assimilation of scientific competence.

Scientific competence

The scientific literacy of citizenship has become a necessity of our society (Garmendia & Guisasola, 2015). To do this, a series of strategies should be promoted from primary education to enable students to acquire skills and abilities in the area of scientific teaching so that they can be applied in any area of daily life that is necessary.

In this sense, we address the term of key competence applied to the educational field. The key competences are one of the fundamental aspects of the curricular approach of the education systems that is increasingly being imposed in the most developed countries due to different actions carried out at international level such as the European Commission of Education (Piñero, Pulido and Falcon, 2017) based on the Delors Report (UNESCO, 1996). It is defined as "know-how" transferred to a diversity of academic, social and professional contexts. The competition integrates a series of factors such as practical skills and conceptual knowledge that, along with motivational, ethical and attitudinal elements and another of social nature are associated with the goal of effective action. Teaching by competences does not imply a change in the curricular elements of the subjects. It is rather a methodological change in which it is required that, in this particular case, the teacher of experimental and life sciences, acquires didactic strategies to implement this type of learning.

Specifically, we will focus on key competences in science and technology that provide better knowledge and responsible interaction with the physical world through actions aimed at the conservation and improvement of the natural environment, necessary for the protection and maintenance for a good quality of life. This competence contributes to the development of scientific thinking, as they include the application of the methods of scientific rationality and technological skills, which lead to the acquisition of knowledge, the contrasting of ideas and the application of the discoveries of social welfare.

Main difficulties that students of primary education have with respect to the learning of experimental sciences and life

There are two factors that could explain this lack of general interest in science (Osborne and Dillon, 2008). First, there is the scarce link between science being studied in school and the reality that the students live; secondly, little information is imparted about how important the sciences are to having a wide variety of careers and exits to the world of work.

It should be noted that in relation to the teaching of experimental sciences, an important place is occupied by teachers. Thus, a study by the OECD (2005) highlights three problematic aspects related to science teachers. On the one hand, the inadequate selection of teachers. In this sense, it is necessary to differentiate between the knowledge or mastery of the subject and the ability to perform the teaching work in the classroom applying the appropriate methodology and pedagogical technique taking into account the characteristics of the students in question. Another factor to take into account, which hampers learning in the experimental sciences and teacher-centered life, is the lack of incentives and flexibility in the teaching career. With this we refer to the low motivation that exists in the teaching career given the few possibilities of promotions that teachers can have access to. Consequently, in many cases it leads to a stagnation of teaching careers. Another factor to be taken into account is the limitations of initial and continuing teacher training, which should focus, among other aspects, on techniques that facilitate the teaching and learning processes of the experimental sciences (Garcia, 2014).

Learning by Inquiry

One of the main premises in the pedagogical methodologies applied in primary education is to maintain a high degree of motivation in the students. In the particular case of science teaching, students should be encouraged to take a positive attitude towards school science that is the source of a link with scientific education. For this reason, it is necessary to promote the investigation of phenomena, facts and theories (Sharp, Peacock, Johnsey, Simon, Smith, Cross & Harris, 2017). As a consequence, it will facilitate observations, questioning of facts, review of various sources of information, linking new knowledge with previous knowledge, analysis and interpretation of results, and reaching conclusions (Pastor, 2014). Therefore, learning by inquiry in the life sciences facilitates the student to develop the attachment to scientific culture taking as its point of departure its more immediate reality as a close element in the didactics of the sciences, suitable to promote meaningful learning (Torres 2010).

The characteristics of learning by inquiry in the field of science are as follows:

- It is based on the constructivist theories of teaching and learning processes, in which the student is the protagonist of their own learning.
- The beginning of the proposal are questions and not affirmations to favor the search of information with the teacher's guide.
- Students create their own questions, obtaining evidence to answer the questions raised and describing the evidence collected.
- Explain the phenomenon that happened from the research process in a reasoned way.

It is important to emphasize that there is a classification by levels depending on the greater or lesser implication and application of the inquiry method, which in turn is linked to the amount of information that teachers offer to their students (Herron, 1971). The four levels are described as follows (Pastor, 2014):

• Inquiry confirmation: the faculty member informs the question and the procedure to be carried out and the results are known in advance; this level is useful for acquiring some specific research skills such as data collection and recording.

• Structured inquiry: as in the first level, the question and procedure is facilitated by the faculty, the difference is that students generate an explanation supported by the evidence they have collected.

• Guided Inquiry: The teacher provides students with only the question to inquire about and the students design the procedure. In this way the students can check the validity of the questions they have asked and the explanations made about the events that took place. The role of the teaching staff is defined at this level as supervisor of the approaches made by the students.

• Open inquiry: at this level students reach higher levels of autonomy, formulating questions, carrying out the design and implementation of research and making the results known.

Pedagogical guidelines for the development of the experimental sciences

The teaching of the experimental and life sciences through a methodology of inquiry, both in teacher training and in primary school, is an effective possibility to do so, because it allows a better understanding of scientific ideas and the way in which scientists study the natural world (Greca, Villagrá and Ojeda, 2017).

Minner, Jurist and Century (2010) perform an analysis of the benefits of the application of inquiry-based methods, concluding that this pedagogical option improves conceptual understanding in relation to traditional theories. However, the presence of inquiry in primary school is scarce in both Spanish-speaking countries (Cortés et al., 2012) and in English-speaking countries (Forbes, 2009), although the trend of recent years is to apply research methodologies in the field of experimental sciences and life in the primary education stage (Greca et al., 2017).

In this section, we are prepared to offer a series of pedagogical guidelines that help to maintain interest and motivation in the classroom because it is an essential factor to encourage the taste for science among children at the elementary stage.

• In the first place, it would be advisable to promote individual or small groups in an autonomous way, favoring the integration of scientific contents in the educational act.

• One factor that promotes the assimilation of scientific competence is to link academic tasks with the problems and situations of everyday life.

• The use of information and communication technologies as a tool for curriculum development taking advantage of all the possibilities of new technologies applied to education (Harasim, 2017).

• It is essential to consolidate the contents of a very extensive program so that students have the opportunity to strengthen concepts, procedures and attitudes. In this sense, it would be necessary to review the curricular contents.

• To take into account the constructivist positions of learning as Weimer, Dowds, Fabricius, Schwanenflugel and Suh (2017), so that the teacher is a facilitating agent in the teaching and learning process while the students are protagonists of their own learning.

Conclusions

As we have been reporting, the attitude of promoting the experimental sciences from school to form part of the culture of society is still insufficient (García, 2014). It is necessary to carry out initiatives oriented to the interest of society by the sciences, creating a true scientific culture. To do this, we propose the increase of teaching hours dedicated to the experimental sciences and of life to be similar to that assigned to materials called instrumental.

On the other hand, future teachers should be aware that curricular contents can become difficult to assimilate especially when using methodologies that do not take into account the evolutionary development of students resulting in demotivation by the subject, the abandonment of the subject and, ultimately, the failure of the school. For this, it is fundamental to propose teaching activities that take into account their abilities, ideas and interests that allow the acquisition of scientific competence and encourage students to enjoy science as in the case of methodology by inquiry.

In this sense, one of the focuses is on the training of future teachers who must overcome the traditional visions of the sciences they have retained as students, as well as the deficits of training in scientific contents that are present in university curricula (Greca et al., 2017).

Disclosure statement

The Authors reported that no competing financial interest.

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