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BIOLOGY TEACHERS TRAINING PROPOSALS FOR THE DEVELOPMENT OF SCIENTIFIC COMPETENCES IN SECONDARY EDUCATION

The acquisition of scientific competences enables students to use knowledge to identify problems, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions on science-related issues. Hence, the importance of its study, in the field of science education, for teacher training and that its exercise in the classroom facilitates it. In our work we review the current state of educational research on the acquisition of scientific competences in the field of biology and at secondary education levels. For this, we have carried out a systematized bibliographic search on the contributions collected in the Web of Science database. A total of 74 articles are found, among them 16 works has been selected according inclusion and exclusion criteria. These works address the need for training of secondary biology teachers in the teaching of scientific competences and provide different approaches to achieve this, based, among others, on the use in the classroom of the characteristics of the nature of science; the use of educational methodologies that promote a greater active participation of students through the approach of problematic situations, as well as that stimulate critical reasoning and argumentation; and the use of activities that raise social controversies with scientific links. Finally, we consider the need for biology teacher training in these aspects that highlight the importance of inquiry as a way of experiencing science in the classroom and developing scientific literacy.

Keywords: Scientific Competences, Teacher Preparation, Science Education

INTRODUCTION

Scientific literacy is one of the main aspects that students must acquire and develop during their education to understand natural sciences and be able to use this knowledge as perceptive, critical and sensible citizens (García-Carmona & Acevedo-Díaz, 2018). This literacy should allow students to reflect, reason and establish connections that will enable them to respond to all those situations they may face in their daily lives (Mkimbili & Ødegaard, 2019).

This perspective requires to build strong links between the content taught in class and the problems of the community; that is, between school science and their daily experiences. In this regard, the subject of biology, on which we focus our attention, can be an excellent opportunity to establish such relationships. In this way, we intend that students can understand the cause and effect of the phenomena that surround them, ask questions about complex problems that compromise their future, make predictions and develop their logical part from a scientific point of view to start functional learning through the development of scientific competence (Levrini et al., 2019).

We must remember that the OECD proposed this term of scientific competence including in it the capacity for inquiry linked to specific contexts and the integration of knowledge; referring to the use that individuals make of scientific knowledge to identify problems, acquire new knowledge, explain phenomena and draw conclusions based on evidence (OECD, 2017). More recently, the Next Generation Scientific Standards (NGSS) are committed to a vision of science teaching and learning that promotes the integration of scientific knowledge, that is, content knowledge, and the necessary practices to participate in scientific research (Tekkumru-Kisa et al., 2019).

Unfortunately, the situation in the classrooms in Spain is still far from achieving these ends and this perspective of work differs significantly from that usually followed in classes. As a consequence, the inquiry capacities are not developed as they should (Banet, 2010).

Given its importance at an educational, social and personal level, in our work we have considered it convenient 1) to study the definition of scientific competence; 2) to know and analyze the research carried out on the training of teachers in scientific competences when working on the contents of biology at the levels compulsory education; and 3) to be able to advance on their teaching difficulties and the most appropriate strategies for their acquisition by students. To do this, we have carried out a systematic review for works that address these issues.

DATA COLLECTION METHODOLOGY

To carry out this work, the team of researchers carried out a search, screening and subsequent analysis of the documents that were obtained. This search was performed with the Web of Science search engine. For this, the search formula was applied with the following criteria: TS = ("scientific competence" OR "scientific competences" OR "scientific practices" OR "scientific competence" OR "learning skills" OR "scientific evidence" OR "scientific literacy") AND TS = ("research"OR"evaluation"OR"evaluation") AND TS = ("biology") OR TI = ("scientific competence"OR"scientific competences"OR"scientific practices" OR "scientific competence"OR "learning skills" OR "Scientific evidence" OR "scientific knowledge") AND TI = ("research" OR "evaluation" OR "evaluation") AND TI = ("biology").

The initial search according to the indicated equation suggested 1,263 documents. To this first selection the expressions "teacher" OR "teachers" were added to focus the search on those who address the participation or training of teachers in their contents. In this second equation, the result was 74 documents, to which we applied the following selection criteria: only area of social sciences; documents in article format; and Spanish (native to the researchers) or English languages. In addition, no restriction was applied on the temporality and the databases consulted were expanded to: Wos, CCC, DIIDW, KJD, MEDLINE, RSCI, SciELO. Thus, the reference population finally reviewed was 51 results. All of these were carefully analyzed by reading the title, abstract, keywords and full content, leaving a final sample of 16 articles that met our requirements. The selected articles were analyzed following the methodology of the PRISMA protocol (Moher et al, 2009).

RESULTS

In a first analysis, we found that most of the selected articles were published from 2016 to the present time (11 of 16). The journals in which these were published are: International Journal of Science Education (3 papers), Science Education (2), Science & Education (2), Research in Science Education (2), CBE Life Sciences Education (2), Journal of Research in Science Teaching (1), Research in Science Technology Education (1), Biological Education Journal (1), Asia Pacific Educational Technology Journal (1), and Teacher Education and Training (1). Most of the authors come from the USA (8 papers), followed by Germany (2), Chile, Denmark, Israel, Slovakia, Thailand and the United Kingdom (1 paper each).

In a more detailed analysis, we have reviewed the definition of scientific competence used in each proposal, the subject matter, the objectives, methodology, the instruments used and the established conclusions, together with the stage and course of the students that may be involved, the number of participants or the geographical scope of the work and other aspects such as economic funding received, public or private centers and the level of education at which the teachers work. In table 1, we show a summary of this data collection in which we highlight the approaches proposed in each analyzed work to promote the acquisition of scientific competences by secondary school students in Biology.

Table 1. Approaches of the analyzed papers and its main features

Approach	Description	No. of Articles
Nature of Science	Influence on science teaching of approaches that take into account the nature of science (NOS) or orientation towards to teaching science (OTS) or the importance of the history of science (HOS)	6
Argumentation and Reasoning Strategies	Influence of strategies that promote reasoning and argumentation (SRA), use of argumentation templates, such as Science Writing Heuristic (SWH), or promote evidence-based reasoning	3
Problematic situations	Inquiry Based Science Education (IBSE)	1
	Problem-Based Learning (PBL)	1
	Investigation-Relation Experiences (IRE) in which students participated	1
Social conflicts of a scientific nature	Activities based on controversial socio-scientific issues (SSI) in the classroom	1
Other methodological proposals	Literature adapted from scientific or popular articles	1
	Scientific skills assessment instruments used by students	1
	Feedback between content knowledge and scientific research	1

A considerable part of the contributions to promote the acquisition of scientific competences by students refer, as we see, to the convenience of teaching approaches that take into account the nature of science in the

classroom. On the other hand, it is also worthy to stress the proposal that refer to the use of problematic situations (research activities, experiments or problems), the approach to controversial situations of social interest, the use of adapted scientific texts or instruments that allow the assessment of the acquisition of research skills.

DISCUSSION AND CONCLUSIONS

The bibliographic review carried out allows us to confirm that the use of didactic proposals based on scientific competences must begin in the first educational stages, bringing science and society closer to students. In this way, we can promote a scientific education that helps train people capable of being an active part in responsible research and innovation, contributing to the education of a scientifically literacy and critical society (Díaz-Moreno et al., 2019). The studies analyzed, despite the variety of proposed objectives, coincide in the need that science teachers move from direct instruction towards student-centered scientific research and science-technology-society frameworks (Zhang & Campbell, 2012). Thus, teacher training should highlight the importance of inquiry as a way of experiencing science in the classroom and developing scientific literacy.

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