

INQUIRY-BASED SCIENCE EDUCATION IN PRIMARY SCHOOL IN SPAIN: TEACHERS' PRACTICES

Javier Montero-Pau y Paula Tuzón

Departamento de Didáctica de las Ciencias Experimentales y Sociales, Facultad de Magisterio, Universidad de València
javier.montero@uv.es, paula.tuzon@uv.es

ABSTRACT: Teaching science by inquiry allows students to develop scientific skills, which is key during primary school, and enhances learning. In this study we present the results of a survey to 63 primary school teachers in Spain about their practices in science class and their knowledge about inquiry-based science education (IBSE). Our results show that concept-based paradigm of science is predominant. Scientific skills, besides observation, are not developed, and the concept of research is restricted to bibliographic search. Teachers believe that IBSE is feasible in the Spanish educative system, although they identify the length of the curriculum and the lack of time are the main obstacles.

KEY WORDS: inquiry-based science, primary school, teachers.

OBJECTIVES: The main goal of this study is to know what is the situation about science teaching in primary school according to teachers' usual practices and education about inquiry. For that, we performed a survey with questions about their general attitudes, their ways of teaching science, their know-how about inquiry as a methodology and their opinion about the viability of this methodology in the Spanish educational system.

THEORETICAL FRAMEWORK

Many of the studies addressing science teaching and learning from the last decades point the need of a change of the science teaching paradigm in primary schools towards an inquiry-based model (IBSE: inquiry-based science education) (Capps & Crawford, 2013; Furtak, Seidel, Iverson, & Briggs, 2012; Harlen & Qualter, 2009; Minner, Levy, & Century, 2010). Learning science by inquiry is coherent with the nature of science, and introduces a strong procedural component in the process of learning, so children are allowed to develop scientific skills, which is key in this educational stage, besides learning concepts (Harlen & Qualter, 2009).

By contrast, the classical paradigm conceives the teaching of science as purely concept oriented. Moreover, this paradigm usually relies on textbooks with a "classical" structure: a first theoretical introduction of a concept and then "practical" exercises or questions (mainly done in the same book) to settle them. While in this classical framework the concept comes in the first place, the inquiry-based teaching place it at the end. In an inquiry-based lesson the order is reversed: first there is a question or motivation of the problem accompanied with an observation scenario, then students make hypothesis

and predictions, design experiments to test them, and, finally, perform their own experiments and draw conclusion (the concept). In this framework students learn and use scientific skills: systematic observation, classification and association, identification of variables that might affect a phenomenon, discrimination of variables, making hypothesis coherent with observations, concreting predictions, designing experiments, distinguishing reliable from not reliable tests, measuring, building conclusions from experimental data, etc.

Many teachers of primary school in Spain are aware of the need of changing the traditional way of teaching sciences, and usually include new methodologies and resources in their science classes. In this study we want to provide an overview of the extent of this paradigm shift in Primary Schools. We aim to answer what teachers do in their science lessons, how many of them have really moved from the classical methodology to inquiry-based science lesson, if they prepare students to acquire scientific skills, and which ones, and what are the main problems that teachers identify to teach by inquiry.

METHODOLOGY

In order to analyse primary school teachers' attitudes, practices and knowledge about inquiry-based science teaching, we developed a survey with 12 closed-ended questions, plus two opened-ended sub-questions to provide examples or clarifications. The survey was sent by email to the 1361 primary schools in Comunidad Valenciana (Spain) in June 2016. The email was addressed to the school management team with the request to forward the survey to all teachers covering the subject *Ciencias de la Naturaleza* (natural sciences). Additionally, the following demographic variables were also recorded: kind of school (state, private or state-subsidised school), religious/non-religious school, town, region, gender, professional experience, course in charge, number of children in class and University where they got the degree.

A brief summary of the questionnaire is presented in Table 1 (original wording can be found on <https://goo.gl/ijKk8>).

Table 1.
Summary of the questionnaire for primary school teachers.

QUESTION	TYPE OF ANSWER
1) Do you like natural sciences?	1 (totally dislike) to 10 (really like)
2) Do you like teaching natural sciences?	
3) Do your students like the subject of natural sciences?	
4) How comfortable do you feel teaching the different parts of the subject? a) environment, b) human body and health, c) living beings, d) matter and energy e) machines	1 (very uncomfortable) to 5 (very comfortable)
5) How is the general structure of your class when you introduce a new concept? a) there is an initial observation/questioning and then a theoretical explanation; b) children search information and then prepare presentations; c) theoretical explanation and then exercises; d) children observe, rise questions and then test them; e) children do demonstrative experiments about what has been explained; f) the teacher does a demonstrative experiment of what has been explained; g) other	1 (never) to 5 (always)
5.1) If you have chosen g) explain how	Open answer
5.2) If you have chosen d) provide an example of what you do and what children do	
6) How frequently do you use a textbook?	0 to 100% of time
A short explanation about what IBSE is provided at this point	

QUESTION	TYPE OF ANSWER
7) Did you know about IBSE?	Yes/No
8) Do you teach science by inquiry?	
9) Do you think IBSE is viable in our educational system?	1 (totally inviable) to 10 (totally viable)
10) What are 3 main limitations you find? a) lack of time; b) the length of the syllabus; c) the curriculum; d) the inspection; e) lack of materials; d) lack of human resources; f) lack of training; g) number of children per classroom; h) other	Choose three items
11) How capable do you feel to teach science by inquiry?	1 (totally incapable) to 10 (totally capable)
12) Are you willing to get training on IBSE?	1 (totally unwilling) to 10 (totally willing)

Answers to question 5.1 were only taken into account if a completely different strategy than those given by question 5 was provided. Answers to question 5.2 were classified into three categories based on how many different scientific skills they work: *inquiry* (I), if they work all scientific skills (see Theoretical Framework); *partial inquiry* (PI), if only a few skills are worked; and *not inquiry* (NI).

RESULTS AND DISCUSSION

The survey was answered by 63 primary school teachers: 74.6% were women, 66.6% had more than 20 years of teaching experience and 68.3% worked in state schools. Half of the teachers teach to 5th/6th courses (47.6% of the samples). Estimated response rate was very low (< 0.3 %). Notice that this is a rough estimate based on the number of teachers in Comunidad Valenciana (c.a. 24,000) (data retrieved from the Spanish Ministry of Education, Culture and Sports Science corresponding to years 2013-2014), and assuming that all teachers received the survey, which is unlikely.

Teacher's attitude towards science (questions 1-3) shows that, in general, they like sciences and teaching science. And there is a positive correlation ($R^2=0.56$, $p\text{-value}<0.001$) between both factors. Interestingly, both factors are also correlated with their perception about their students liking science; the more they like teaching science, the more they think their students like the subject ($R^2=0.26$, $p\text{-value}<0.001$). In general, teachers feel significantly more comfortable (question 4) with topics related to environment, human body/health or living beings, than to topics related to matter and energy or machines (Kruskal-Wallis rank sum test, $p\text{-value}<0.001$). This result is in line with secondary school students' preferences (Solbes, 2011), and it will be interesting to further study if there is a link between primary school teachers' preference and secondary students.

Teachers structure their science classes (question 5) in different ways. The frequency of use of the different teaching strategies varies (Kruskal-Wallis rank sum test $p\text{-value}<0.001$). The most frequently used strategies are either using an initial observation and questioning following with a classical approach or students do presentations after seeking information about a concept (e.g., Internet) (5a and 5b). After these strategies, the two more common are either the students or the teacher do demonstrative experiments as an application of the concept that has been explained (5e and 5f). Finally, the less frequent are the purely classical approach (i.e., explaining a concept and then activities to reinforce), and what teachers understand as an "inquiry-based approach" (5c and 5d). None of the answers alleging using other strategies (question 5.1) was in fact different from those proposed in question 5, and all of them could be assigned to one of the pre-defined strategies.

Some of the teachers declare to use an inquiry-based approach, however, the examples provided (question 5.2) show that they mainly use observation as a motivating starting activity, but not as a part of an investigation. Teachers also tend to confuse “investigating” with “searching on the Internet” (e.g., “We start with motivating questions and then students search the information by themselves (on the Internet or wherever)”). They also confuse investigation with “children doing things”, no matter what. In other cases, teachers describe examples of inquiry as situations where children or teachers do experiments but are completely demonstrative, i.e. guided steps to show how some phenomenon happens. There is no investigation in any sense. Children do not decide how to test their hypothesis, which of the variables involved in a phenomenon they need to vary or keep fixed, they do not perform experimental designs or discuss about what is a reliable test. In short, children do not do experiments in the scientific sense. The high frequency of “non-classical” methodologies should be taken with caution, as a bias can exist in this kind of surveys; more innovative teachers could be more willing to participate in studies.

The principal component analysis (PCA) based on the use of the different strategies show that the two first principal components (60% of the total variance) are related to involving more/less the children in the learning process (PC1) and doing/not doing experiments (although demonstrative) (PC2). Two different groups can be found in the PCA, teachers that use strategies where children are more involved and perform demonstrative experiments, and on the other hand, teachers using a more classical approach, with less children involvement and use of demonstrative experiments.

After reading a text explaining what IBSE is, which are the scientific skills and how they should be taught to children, 30% of teachers claim they already know what IBSE was and 30% consider that they apply IBSE in class (questions 7 and 8). These results contrast with question 5, where 86% of them claim to use at some point an inquiry-based strategy; however, this frequency drops to a 30% after reading about it. This, together with fact that none of the examples of an “inquiry lesson” is really an inquiry lesson (see above), shows that teachers do not fully understand what inquiry means.

In general, teachers are positive regarding the viability of inquiry-based teaching (question 9) (50% score 7/8 in this question and 20% score 5/6). Nevertheless, they identify the lack of time (73.0% of teachers), lack of material resources (57.1%) and extension of the syllabus (52.4%) as the three main obstacles to implement IBSE in the Spanish educational system. Lack of time assigned to science, which is also related to the extension of the syllabus, is a major drawback for IBSE. Students require time to develop the scientific skills. Time allocated to science in primary schools in the Spanish system is between 1.5 and 2 hours per week (depending on the regional regulations). Moreover, this problem is aggravated with two common situations: i) lack of curricular interaction, subjects are mainly regarded as independent entities, and ii) strict timetables, so joining the assigned time to science into a longer single lesson is sometimes difficult. Thus, a more flexible organization of timetables, and higher interaction among subjects (IBSE is especially suited to work transverse topics) can alleviate this problem. Another of the main teachers' concerns regarding viability of IBSE is related to the curriculum, either to the extent of the syllabus (e.g., “It is impossible to work on scientific skills with so many contents to cover”) or the selection of topics to teach. However, the description of concepts and the depth in which they have to be covered on the law that regulates the Spanish curriculum is not very extensive, and it would allow teachers to design lighter curricula. This is not the case of primary school textbooks, which tend to cover mandatory concepts in a higher depth, sometimes repeating concepts course after course, resulting in lengthier and denser curricula. Interestingly, our results show a trend that teachers that use textbooks more often also tend to recognise the extension of the syllabus as a limiting factor, however differences were not statistically significant (Fisher test p-value=0.157) probably because of a lack of statistical power due to low sample size. In future studies, it will be interesting to study this relationship among use of textbooks and perception of the curriculum with more detail. Finally, teachers

also refer the lack of material resources such as lab equipment as another main problem. It is probably true that an inquiry approach would require more resources than a chalk-talk approach, however most of the investigation that can be performed with children will only require common materials such as water, plastic ware, cardboard, rules, dough, clay...

Only 34.9% of teachers point lack of preparation to teach through inquiry as one of the three main obstacles to IBSE. On average, they feel capable to use an inquiry-based approach (mean \pm standard error: 7.1 ± 0.2). This autoconception is not correlated with their teaching experience, but it is correlated with the frequency of the use of textbook ($R^2=0.13$, $p\text{-value}<0.001$). The more they rely on textbooks the less capable they feel. In general, teachers are willing to receive specific training to teach through inquiry (mean \pm standard error: 8.4 ± 0.2).

CONCLUSIONS

Our results show that the concept-based traditional paradigm of science teaching is still predominant. In general, science classes are traditional with some demonstrative experiments and/or motivating starting questions or observations; but there are not investigations where the learning of concepts and science process skills are integrated in a coherent sequence of steps (Pérez, 1983). Among those teachers that use methodologies with a greater involvement of students, observation is the only scientific skill that is developed, and the concept of research is restricted to searching bibliographic information. Teachers find that IBSE is feasible in the Spanish educative system, although they think that the curriculum and the lack of time are the main obstacles. Surprisingly, despite they did not previously know what IBSE was, and that those that declare to use it do not really perform inquiry, teachers do not recognize lack of training as a main obstacle. Teachers feel capable to teach through inquiry and they are positive to the idea of getting specific training.

BIBLIOGRAPHY

- CAPPS, D. K., & CRAWFORD, B. A. (2013). Inquiry-Based Instruction and Teaching About Nature of Science: Are They Happening? *Journal of Science Teacher Education*, 24(3), 497–526. doi:10.1007/s10972-012-9314-z
- FURTAK, E. M., SEIDEL, T., IVERSON, H., & BRIGGS, D. C. (2012). Experimental and Quasi-Experimental Studies of Inquiry-Based Science Teaching: A Meta-Analysis. *Review of Educational Research*, 82(3), 300–329. doi:10.3102/0034654312457206
- HARLEN, W., & QUALTER, A. (2009). The Teaching of Science in Primary Schools. In D. Fulton (Eds.). Oxon, OX: Routledge.
- MINNER, D. D., LEVY, A. J., & CENTURY, J. (2010). Inquiry-based science instruction-what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching*, 47(4), 474–496. doi:10.1002/tea.20347
- PÉREZ, D. G. (1983). Tres paradigmas básicos en la enseñanza de las ciencias. *Enseñanza de las ciencias: revista de investigación y experiencias didácticas*, 1(1), 26–33.
- SOLBES, J. (2011). ¿Por qué disminuye el alumnado de ciencias? *Alambique: Didáctica de las ciencias experimentales*, 67(1), 53–61.

