

HOW SPANISH SCIENCE TEACHERS PERCEIVE THE INTRODUCTION OF COMPETENCE-BASED SCIENCE TEACHING

**Antonio Mateos Jiménez,
Beatriz García Fernández,
María Teresa Bejarano Franco**

Introduction

The 2006 Education Law (LOE, 2006) introduced a competence-based education model in Spain that continued under the LOMCE Education Law (2013). This model sought to develop eight key competences, thereby contributing to a change in education paradigm advocated by the European Union (Halász & Michel, 2011; Looney & Michel, 2014). The eight key competences considered for primary (ages 6-12) and secondary (ages 12-16) education curricula were in the areas of linguistic communication, mathematics, data processing and digital data, social skills and citizenship, cultural and artistic learning, learning to learn, autonomy and personal initiative, and knowledge of and interaction with the physical world (LOE, 2006). The last of these referred to competence in science, considered basic in the OECD's (2005) DeSeCo project along with mathematics and reading. Teaching, using a scientific competence approach, basically provided students with functional learning, encouraging the development of skills and enabling them to understand how scientific knowledge was generated and how it applied to everyday life (Grandy & Duschl, 2007). Developing a competence-based model should be an opportunity to consider actions aimed at improving the teaching-learning processes (Vilches & Gil, 2010) and also for teachers to re-examine what they did in their professional lives (Sanmartí, 2010). The competence-based model should encourage the acquisition of skills, attitudes and values (Furió, Vilches, Guisasaola & Romo, 2001), contextualizing what was learned in the classroom using real problems (Alake-Tuenter, Biemans, Tobi, Wals, Oosterhert & Mulder, 2012; Schweingruber, Keller & Quinn, 2012).

Involving the teachers as direct agents to apply the curriculum is fundamental when it comes to evaluating the results of curriculum reform (Broadhead, 2002; Roehrig, Kruse & Kern, 2007). Various papers have noted that the success of education reforms largely depends on the attitude, emotions and commitment of the teachers towards the measures proposed in any new legislation (Kelchtermans, 2005; Carlgren, Klette, Myrdal, Schnack & Simola,



JOURNAL
OF BALTIC
SCIENCE
EDUCATION

ISSN 1648-3898

Abstract. *The aim of the research was to determine how teachers in Spain perceived the introduction of competence-based science teaching in the classroom. The research was carried out during the transition between the LOE and LOMCE Education Laws (academic year 2014-2015). Data were collected using an ad hoc questionnaire comprising 19 items requiring responses on a 5-point Likert scale. The sample comprised 443 science teachers in compulsory education in Spain. The results indicated that the way teachers perceived science and its scope and application in the classroom was unlikely to lead to the effective development of the scientific competence. Significant findings were discussed relating to the participating teachers' initial training, gender, type of school and stage of education. As a final component the didactic implications of teaching scientific competence were considered.*

Key words: *primary education, scientific competence, secondary education, teachers' perceptions, science teachers.*

**Antonio Mateos Jiménez,
Beatriz García Fernández,
María Teresa Bejarano Franco**
University of Castilla-La Mancha, Spain



2006; McCormick, Ayres & Beechey, 2006; Roehrig et al., 2007). This also applies to the change to a competence-based education model (Gordon et al., 2009).

A number of researchers have analysed the process whereby educational competences are applied in Spain (Méndez-Giménez, Sierra-Arizmendiarieta & Mañana-Rodríguez, 2013; Monarca & Rappoport, 2013; Ezquerro, De-Juanas & Ulloa, 2014; Méndez-Alonso, Méndez-Giménez & Fernández-Río, 2015; Lleixà, González-Arévalo & Braz-Vieira, 2016). Proposals have also been put forward regarding working on and evaluating competence in science (Cañal, 2012; Pedrinaci, Caamaño, Cañal & Pro, 2012; Pedrinaci, 2013; Blanco-López, España, González-García & Franco, 2014; Franco, Blanco & España, 2014). Other research has revealed the influential role played by the beliefs and opinions of Spanish teachers in changes made to science education (Banet, 2007; 2010). It has also been shown that gaining competence in science is more difficult than content-based learning (Benarroch & Núñez, 2015).

Research Focus

Although the competence-based approach has been in place for almost a decade in compulsory education in Spain, few papers have analysed teachers' opinions on the introduction of the model. And as far as competence in science is concerned, no research has looked specifically at how Spanish teachers involved in science teaching perceive the change, despite the fact that the success of competence-based education reforms depends, to a large extent, on teachers' perceptions (Gordon et al., 2009).

Regarding the foregoing, the main objectives of the research were:

- a) to identify compulsory education science teachers' perceptions of teaching aimed at developing scientific competence in Spain at a time when legislation on education is changing, and
- b) to discover whether there are differences in perceptions among teachers, taking into account variables such as the gender, age and experience of the participants, stage of education, type of contract and type of school.

Methodology of Research

General Background of Research

The competence-based model in Spain was set up in 2006, but during the following decade teachers received no training programs specifically aimed at effectively implementing the change. The education law applied to the country as a whole, but each of the nineteen regions was able to specify how the curriculum was to be developed by passing decrees based on the national law. The science teacher population in Spain totalled 376.474 (MECD, 2015) and were geographically distributed by region, as follows: Andalucía (18.9%), Aragon (2.8%), Cantabria (1.3%), Castilla-La Mancha (4.6%), Castilla and León (5.1%), Catalonia (15.8%), Ceuta (0.2%), Community of Madrid (12.9%), Valencian Community (10.4%), Extremadura (2.5%), Galicia (5.8%), Balearic Islands (2.4%), Canary Islands (4.1%), La Rioja (0.7%), Melilla (0.2%), Navarre (1.6%), Basque Country (5.1%), Principality of Asturias (2.0%) and Murcia (3.6%) (MECD, 2015).

A qualitative methodology, with quantitative approximation, was used to carry out the research, and a questionnaire was the instrument chosen for data collection.

Sample Selection

The participant sample consisted of 443 teachers, designed to be representative of the science teacher population with a 95% confidence level and a 5% margin of error. The sample was chosen at random, taking into account the percentage geographical distribution by region needed to be representative of the Spanish context (MECD, 2015).

The mean age was 44.5 years (standard deviation-SD=9.0) and the mean teaching experience 17.1 years (SD=10.0). 19.9% were on temporary contracts and 80.1% permanent. 40.1% were primary and 59.9% secondary teachers. 73.8% of the sample worked in state schools and 24.6% in private state-funded schools (1.6% did not answer the question). 63.0 % were women and 37% men.



Instrument and Procedures

An *ad hoc* questionnaire was designed for the research. The clarity and relevance of the items were first checked by a panel of 9 experts in pedagogy and science education. The questionnaire was in two parts. The first part collected descriptive data about the participants: region, gender, age, professional experience, stage of education (primary or secondary), type of contract (permanent or temporary) and type of school (public or private state-funded).

The second part included a 5-point Likert scale (Table 1). In questions 1-11, teachers were required to score each item according to its importance in developing the students' scientific competence. The scores considered were: 1 Very low, 2 Low, 3 Neither high nor low, 4 High and 5 Very high. Teachers then scored items 12-19 according to the following criteria: 1 Strongly disagree, 2 Disagree, 3 Neither agree nor disagree, 4 Agree and 5 Strongly agree.

The Cronbach's alpha value (0.922) confirmed the instrument's reliability and high internal consistency. The Kaiser-Meyer-Olkin statistic (0.929) and Bartlett's sphericity test ($\chi^2=3888.751$, $p<0.001$, $df=171$) on the suitability of the sample indicated the appropriateness of carrying out an exploratory factor analysis. This factor analysis revealed three dimensions consistent with those conceptually considered in the design of the questionnaire:

- I) perception of the importance of science dimensions for indicating the development of scientific competence (questions 1 to 11);
- II) perception of science education's contribution to the development of other key competences (questions 2 to 16); and
- III) implementation of the competence-based model and its importance for understanding the interaction between humans and the medium in which they live (questions 16 to 19).

The validation results showed that the construct could be accepted as valid and the instrument as reliable, and therefore the values resulting from applying the instrument could be interpreted as expressing the latent dimensions that make up the construct.

The questionnaire was implemented on the Google Forms platform. It was applied digitally. The link was sent out by email in November 2014, followed by two reminders in January and February 2015. The data were collected between November 2014 and May 2015.

Data Analysis

The data were analysed using IBM SPSS Statistics 19.0 software. A descriptive analysis of all the items was conducted. A Kolmogorov-Smirnov test was carried out to determine whether to apply parametric or nonparametric statistics procedures. The criteria of normality were not satisfied for all items, so nonparametric statistical procedures were used: the Mann-Whitney U and Kruskal-Wallis tests were used for two or more independent samples respectively.

Results of Research

The descriptive statistics (mean and standard deviation) for the different items and the dimensions that comprise them are shown in Tables 1 and 2 respectively. The values for each dimension were obtained by calculating the mean for each subject from the answers given to the items that cover each dimension.

From looking at the results, it could be seen that the teachers gave moderate ratings for the different items and dimensions considered, since the mean values ranged from 3.09 to 4.23. The dimension with the highest ratings concerned science's contribution to the development of the other key competences (dimension 2), with a mean value of 4.01. The participants also gave moderate ratings for the various components of scientific competence (dimension 1, mean value 3.90). Scoring a lower average was the dimension covering the implementation of the competence-based model (dimension 3, mean value 3.62).



Table 1. Descriptive statistics for the items included in the Questionnaire on applying the competence-based teaching model in the sciences in compulsory education.

Items of the questionnaire	Mean	SD
1. To appropriately describe everyday situations in which scientific knowledge plays a part.	3.95	0.87
2. To acquire skills for analysing and resolving problem situations in one's natural surroundings.	4.06	0.89
3. To recognize the importance of relationships between science, technology and society (STS).	3.80	0.87
4. To use science vocabulary correctly.	3.67	0.89
5. To recognize and appreciate the importance of scientific knowledge in solving global problems.	3.88	0.90
6. To use information and communications technologies (ICT) as a source of information for solving problems and cases and as a means of communicating results.	3.98	0.87
7. To know how to apply the content of the science curriculum.	3.87	0.88
8. To tackle scientific problems in a multidisciplinary way.	3.92	0.95
9. To value the natural environment and act in favour of conservation and sustainable development.	4.23	0.84
10. To recognize science as a human construct, another form of knowledge.	3.91	0.90
11. To understand how scientific information is generated and evolves.	3.64	0.90
12. Sciences contribute to the development of the other key competences because they enable one to interpret and describe one's surroundings.	4.03	0.82
13. Sciences contribute to the development of the other key competences because they encourage procedures of generalization and experimentation.	4.07	0.79
14. Sciences contribute to the development of the other key competences because they develop technical and operational skills.	3.94	0.78
15. Sciences contribute to the development of the other key competences because they precisely define concepts and procedures and systematize observations.	3.98	0.81
16. Sciences contribute to the development of the other key competences because they enable answers to be found to the questions through problem-solving and case studies in a variety of contexts.	4.05	0.76
17. The curriculum for competence-based knowledge of the environment must be based on a functional approach to learning sciences.	3.84	0.94
18. It is relatively easy to find or design tasks to encourage the development of competence in knowledge of and interaction with the students' physical world.	3.09	1.00
19. Competence in knowledge of and interaction with the physical world helps one to understand the interaction between humans and the medium in which they live.	3.95	0.85

Table 2. Mean and standard deviation of the dimensions covered by the questionnaire.

Dimensions of the questionnaire	Mean	SD
Dimension 1. Specific aspects or dimensions in the area of sciences serving to indicate the development of competence in knowledge of and interaction with the physical world.	3.90	0.67
Dimension 2. The contribution of sciences to the development of the other key competences.	4.01	0.68
Dimension 3. Implementation of the competence-based model and its importance for understanding the interactions between humans and the world in which they live.	3.62	0.68



The items with the lowest ratings were 17 "The curriculum for competence-based knowledge of the environment must be based on a functional approach to learning sciences" (mean value 3.84) and 18 "It is relatively easy to find or invent tasks to encourage the development of competence in knowledge of and interaction with the students' physical world" (mean value 3.09). Both refer to the implementation of the competence-based model. The items with the highest ratings were 9 (on conservation and sustainable development, mean value 4.23) and 2 (on solving environmental problems, mean value 4.06).

An equality of means test was carried out for gender. Significant differences were observed in dimension 1 ($p=0.030$; $U=20172.500$; $W=34033.500$; $Z=-2.164$) and items 1 ($p=0.016$; $U=20027.000$; $W=33888.000$; $Z=-2.413$), 7 ($p=0.047$; $U=20547.000$; $W=34408.000$; $Z=-1.983$), 9 ($p=0.007$; $U=19716.000$; $W=33577.000$; $Z=-2.715$), 12 ($p=0.038$; $U=20498.000$; $W=34359.000$; $Z=-2.070$), 16 ($p=0.013$; $U=20009.500$; $W=33870.500$; $Z=-2.482$) and 19 ($p=0.029$; $U=20326.000$; $W=34187.000$; $Z=-2.179$) (Table 3). It was found that women gave higher ratings for these items (table 3).

Table 3. Descriptive statistics according to gender for items where statistically significant differences ($p < 0.05$) were found.

		Item 1	Item 7	Item 9	Item 12	Item 16	Item 19	Dimension 1
Men	Mean	3.84	3.77	4.08	3.93	3.92	3.84	3.81
	SD	0.82	0.91	0.90	0.85	0.82	0.88	0.69
Women	Mean	4.01	3.93	4.32	4.09	4.13	4.02	3.94
	SD	0.89	0.86	0.79	0.80	0.71	0.83	0.66

Equality of means tests were also carried out for age (in years: ≤ 30 , 31-40, 41-50, 51-60 and > 60) and professional experience (in months: ≤ 120 , 121-240, 241-360, 361-480 and > 480). A statistically significant correlation was found between both variables considering the categories shown above (Spearman coefficient= 0.766 , $p < 0.01$). No significant differences were found in any of the items as regards age and professional experience.

Significant differences occurred between primary teachers (generalists) and secondary teachers (specialists in science education), with a significance level of 0.05 in items 1 ($p=0.006$; $U=18688.500$; $W=34619.500$; $Z=-3.877$), 3 ($p=0.000$; $U=19006.000$; $W=34937.000$; $Z=-3.608$), 4 ($p=0.004$; $U=19945.500$; $W=35876.500$; $Z=-2.861$), 5 ($p=0.005$; $U=20010.000$; $W=35941.000$; $Z=-2.798$) (though with no statistically significant differences for dimension 1 which encompasses them), 16 ($p=0.039$; $U=20991.500$; $W=36922.500$; $Z=-2.064$) and 17 ($p=0.023$; $U=21586.000$; $W=56566.000$; $Z=-1.518$) (Table 4). Secondary teachers gave higher ratings than primary teachers (table 4) for the importance of the specific science dimensions reflected in the items for developing scientific competence, but the opposite happened with item 17, concerning the functional approach to scientific competence.

Table 4. Descriptive statistics according to stage of education for items where statistically significant differences were found ($p < 0.05$).

		Item 1	Item 3	Item 4	Item 5	Item 16	Item 17
Primary	Mean	3.78	3.63	3.54	3.75	3.95	3.98
	SD	0.80	0.84	0.82	0.86	0.82	0.87
Secondary	Mean	4.06	3.54	3.75	3.97	4.12	3.76
	SD	0.90	0.88	0.92	0.91	0.71	0.97

As far as type of contract is concerned, statistically significant differences were found only in item 4 ($p=0.025$; $U=13346.500$; $W=17262.500$; $Z=-2.245$), with higher ratings being awarded by permanent teachers (mean= 3.71 ; $SD=0.90$) than by those on temporary contracts (mean= 3.51 , $SD=0.83$).

Statistically significant differences were found, related to the type of centre, for items 1 ($p=0.013$; $U=15153.500$; $W=21148.500$; $Z=-2.484$), 2 ($p=0.017$; $U=15263.500$; $W=21258.500$; $Z=-2.387$), 8 ($p=0.027$; $U=16589.000$; $W=22584.000$; $Z=-2.205$), 9 ($p=0.005$; $U=14863.500$; $W=22692.500$; $Z=-2.810$), 12 ($p=0.031$; $U=15545.500$; $W=21540.500$; $Z=-2.162$), 17 ($p=0.013$; $U=15150.000$; $W=21145.000$; $Z=-2.476$) and 19 ($p=0.013$;



U=15170.000; W=21165.000), and in dimensions 1 ($p=0.046$; U=15552.500; W=21547.500; Z=-1.994) and 3 ($p=0.039$; U=15498.500; W=21493.500; Z=-2.063).

Table 5. Descriptive statistics according to type of centre for items where statistically significant differences were found ($p < 0.05$).

		Item 1	Item 2	Item 8	Item 9	Item 12	Item 17	Item 19	Dimension 1	Dimension 3
Public	Mn	4.00	4.12	3.97	4.30	4.08	3.91	4.00	3.93	3.66
	SD	0.87	0.87	0.96	0.81	0.82	0.95	0.87	0.67	0.72
Private State-funded	Mn	3.77	3.89	3.78	4.05	3.91	3.68	3.79	3.80	3.31
	SD	0.85	0.93	0.89	0.89	0.78	0.88	0.80	0.69	0.67

Discussion

The frequent changes in legislation on education in Spain provide an opportunity to study the impact of these changes on curricula (Pro & Nortes, 2016). And, as pointed out by López Ruiz (2011) and Bejarano and Rodríguez Torres (2016), competence-based teaching is undoubtedly one of the biggest changes to have taken place in education in Spain in recent years, demanding a special effort from teachers in all stages of the system.

The results of the research indicate that Spanish teachers do not perceive the full potential of the competence-based model in science, claiming that it is difficult to implement in the classroom. In Spain, these results are not exclusive to scientific competence, but are in line with other results involving the key competences in general (Méndez-Giménez et al., 2013; Méndez-Alonso et al., 2015), and competence in physical education in particular (Lleixà et al., 2016).

The different dimensions inherent in competence-based science education were, in general, given a moderate score by participants. However, there were certain, basic formative elements associated with science and learning science that the teachers scarcely valued. These elements were the *nature of science, the relationships between science, technology and society, and the genesis and evolution of scientific knowledge*. This perception of science went against National Research Council recommendations (Michaels, Shouse & Schweingruber, 2007), as well as the conclusions drawn by García-Carmona, Vázquez and Manassero (2012) and Köksal and Şahin (2014). Both papers argued that studying the nature of science was essential in order for citizens to become scientifically literate and that it should be reflected throughout the entire school science curriculum. For Honey, Pearson and Schweingruber (2014), promoting a contextualized view of science increased students' interest and encouraged scientific vocations.

The importance of using scientific vocabulary was another element poorly perceived by the participants. This stands in contrast to the value of science vocabulary as a part of scientific competence (Yore & Treagust, 2006; OECD, 2007) and as a teaching tool (Wellington & Osborne, 2001). As demonstrated by Jeppsson, Haglund and Strömdahl (2011), an appropriate knowledge and use of the language made it easier to learn science. The teachers surveyed were also unsure about the current dimension of science as an instrument to be used for global social problems and as contributing to capacities for studying the environment. Neither did most of them perceive the connection between science and ICT. This clearly went against what was currently accepted in the literature (OECD, 2002, Schweingruber et al., 2012; Partnership for 21st century learning, 2015) and highlighted the fact that a traditional view of science still persisted in the minds of many teachers.

As regards the curriculum, the participants were not certain about how scientific competence contributed to the development of the other key competences. This result matched those described by Méndez-Giménez et al. (2013), Méndez-Alonso et al. (2015) and Lleixà et al. (2016), who were also unable to find, in teachers, the necessary didactic connection between the competencies included in the competence-based model. This could indicate that a fair proportion of teachers lacked the holistic, interdisciplinary vision that the competence-based teaching model required, reinforcing the idea that the model had been misinterpreted and that knowledge continued to be worked on in separate areas with no influence transferring between the various key competences.

Another finding showed that the participants were not completely convinced about the functional approach that characterized competence-based learning in science. These were probably teachers who adopted



the competence-based model, but still held traditional views about how science was taught in the classroom (Gil & Vilches, 2006). This mismatch between science teachers and the new demands of the competence-based model was also noted in other research (Mendoza & Rodríguez-Pineda, 2009; Sharp, Hopkin & Lewthwaite, 2011). Bearing in mind the research by Martínez Galáz and González Weil (2014), on the persistence of views on teaching sciences, it was understandable why some teachers were reluctant to change the way they “are” and the way they “do” as regards science teaching. While not ruling out the influence of other factors, it was no surprise that this resistance to change on the part of the teachers made it more difficult to meaningfully introduce scientific competence to the students. Introducing immersion into the competence-based model might have come about in Spain unaccompanied with the necessary changes in how teachers believed science education needed to be carried out.

The results of the research show that the teachers surveyed do not find it easy to carry out tasks that encourage scientific competence. Lee, Abd-El-Khalick and Choi (2006) and Sharp et al. (2011) indicate similar results in Korea and England respectively. As Benarroch and Núñez (2015) point out, it needs to be remembered that competence-based science teaching is more complicated than teaching specific content and calls for expert teachers. Ko and Lee (2003), Bonil and Márquez (2011) and Franco, Blanco and España (2014) are therefore along the right path in stressing that teacher training needs to include content focusing on how to design and use classroom tasks and practical science activities. This is because it is in the actual teaching that the change to a competency-based model needs to be reflected (Sierra-Arizmendiarieta, Méndez-Giménez & Mañana-Rodríguez, 2013). As argued by Özdem, Çavaş, Çavaş, Çakiroğlu and Ertepinar (2010) and Mateos and Ruiz-Gallardo (2016), teachers need to know how to teach science on the basis of everyday activities and students’ familiarity, and there is a need for specific initial and permanent training in competence (Lamanauskas & Augienė, 2009; García-Ruiz & Castro, 2012), as opposed to training based on traditional approaches (Martín, Prieto & Lupión, 2014; Martín, Prieto & Jiménez, 2015).

No statistically significant differences emerge in segmentation variables as regards age, professional experience or type of contract. However, papers, such as those by Méndez-Alonso et al. (2015) and Lleixà et al. (2016), indicate that the longest-serving teachers have the most difficulty in implementing the competence-based model. Younger teachers, with less experience, take a more positive view towards the introduction of new working methods, although the conclusions in these papers do not refer specifically to scientific competence. Meanwhile, Sharp et al. (2011) find that teachers in senior management positions, with wider experience and participating in in-training, or supervising the science curriculum implementation, hold a more favourable perception of the reform. Considering these results, further research is needed to explore the differences involving these variables.

Statistically significant differences related to gender are found, in line with those seen in other contexts by Hargreaves (2003), Méndez-Alonso et al. (2015) and Lleixà et al. (2016), who maintained that women are more predisposed and adapted better to the competence-based model. Haney, Czerniak and Lumpe (1996) and Sharp et al. (2011) come to similar conclusions in the field of science education and stress the importance of considering the gender dimension in educational matters involving science.

As for the type of school, the results of the research reveal that teachers in public schools give higher ratings than those in private state-funded schools. This is new data in that until now, in Spain, there has been no analysis of competence-based science education according to type of school. Future research needs to look more closely at this variable and the possible reasons for these results.

The stage of education in which the teachers work also reveals significant differences. Secondary school teachers (science specialists) are more sensitive to science-related aspects and their characteristics than primary school teachers (generalists), and this may have something to do with their initial training. This perception is not limited to scientific competence, since work carried out by Méndez-Giménez et al. (2013) and Méndez-Alonso et al. (2015) points in the same direction, when taking key competences as a whole into account.

However, primary teachers have a better perception of the functional approach to learning sciences. To explain this result, it may be that primary teachers receive training which, while less specific, is more crosscutting, and they gain more teaching experience in various knowledge areas. This may enable them to be more flexible and more likely to accept the change in methodology because, in line with the ideas of Haney et al. (1996), the competence-based model requires an effort to follow a more student-centred style of science teaching, and primary teachers typically have beliefs that encourage this type of instruction.



Conclusions and Implications

The present research, carried out at a time when the education law that introduced the competence-based model (LOE) reached full implementation, makes it possible to conclude that, after ten years of working with competences in Spain, the model is not being implemented effectively. Teachers in compulsory education still seem to have a traditional perception of science education, they do not fully accept the functional approach of science, and they have problems when it comes to finding and designing tasks to use in the classroom. However, statistical difference emerged between gender, with women more amenable to the new developments and in the type of school, with primary school teachers more disposed to the competence-based approach.

In Spain, the implementation of the LOE education law was not followed by a training programme to provide teachers with the tools to effectively develop this model in schools. Experience alone seemed not to be enough and should be accompanied by training as far as scientific competence was concerned, over and above any changes in legislation that might be introduced. In this regard, coordination between institutional and educational actions aimed at consolidating competence-based teacher training was in need of improvement. These results could provide useful information for other EU countries in the process of introducing or consolidating competence-based teaching models.

It seems undeniable that, in order to promote education in STEM (science, technology, engineering and mathematics) and make progress in making people scientifically literate, educational policies need to take into account the perceptions of the professionals working in the field, providing teachers with the tools they need to implement the changes. If all the agents of education involved do not succeed in making teachers - whether in training or working - perceive that scientific competence is an innovative way of approaching science teaching, then the competence-based model may end up as a series of didactic routines guided by traditional teaching practices, thereby turning the new model into nothing more than a cosmetic change.

Acknowledgements

The authors are grateful to the Spanish Ministry of Education, Culture and Sport for the funding received via the project "Contextual study of teachers' difficulties in teaching focused on the development of competences" (EDU2012-3389, a competitive grant programme for RDI 2008-2011). The authors also like to thank the teachers who participated in this research.

References

- Alake-Tuenter, E., Biemans, H. J. A., Tobi, H., Wals, A. E. J., Oosterherdt, I., & Mulder, M. (2012). Inquiry-based science education competencies of primary school teachers: A literature study and critical review of the American National Science Education Standards. *International Journal of Science Education*, 34 (17). doi: 2609-2640. 10.1080/09500693.2012.669076.
- Banet, E. (2007). Finalidades de la educación científica en secundaria: opinión del profesorado sobre la situación actual [Objectives of science education in secondary education: Teachers' opinions of the current situation]. *Enseñanza de las Ciencias*, 25 (1), 5-20.
- Banet, E. (2010). Finalidades de la educación científica en educación secundaria: aportaciones de la investigación educativa y opinión de los profesores [Objectives of science education in secondary education: Contributions of education research and teachers' opinions]. *Enseñanza de las Ciencias*, 28 (2), 199-214.
- Bejarano, M., & Rodríguez Torres, J. (2016). La formación pedagógica de futuros maestros y maestras: otros ámbitos para la actuación [Pedagogical training of future teachers: Other areas for action]. In A. Mateos & A. Manzanares (Eds.), *Mejores maestros, mejores educadores [Better teachers, better educators]* (pp. 49-75). Malaga, Spain: Aljibe.
- Benarroch, A., & Núñez, G. I., (2015). Aprendizaje de competencias científicas versus aprendizaje de contenidos específicos. Una propuesta de evaluación [Learning of scientific competences versus learning of specific contents. An assessment proposal]. *Enseñanza de las Ciencias*, 33 (2), 9-27. doi: 10.5565/rev/ensciencias.1578.
- Blanco-López, A., España, E., González-García, F. J., & Franco, A. J. (2014). Key aspects of scientific competence for citizenship: A Delphi study of the expert community in Spain. *Journal of Research in Science Teaching*, 52 (29), 164-198. doi: 10.1002/tea.21188.
- Bonil, J., & Márquez, C. (2011). ¿Qué experiencias manifiestan los futuros maestros sobre las clases de ciencias? Implicaciones para su formación [What experiences do future teachers mention regarding science lessons? Implications for their training]. *Revista de Educación*, 354, 447-472.
- Broadhead, P. (2002). The making of a curriculum: How history, politics and personal perspectives shape emerging policy and practice. *Scandinavian Journal of Educational Research*, 46 (1), 47-64. doi: 10.1080/00313830120115606.



- Cañal, P. (2012). Cómo evaluar la competencia científica? [How should competence in science be assessed?]. *Investigación en la Escuela*, 78, 5-17.
- Carlgrén, I., Klette, K., Mýrdal, S., Schnack, K., & Simola, H. (2006). Changes in Nordic teaching practices: From individualised teaching to the teaching of individuals. *Scandinavian Journal of Educational Research*, 50 (3), 301-326. doi: 10.1080/00313830600743357.
- Ezquerro, A., De-Juanas, A., & Ulloa, C. S. M. (2014). Teachers' opinion about teaching competences and development of students' key competences in Spain. *Procedia Social and Behavioral Sciences*, 116 (1), 1222-1226. doi: 10.1016/j.sbspro.2014.01.372.
- Franco, A. J., Blanco, A., & España, E. (2014). El desarrollo de la competencia científica en una unidad didáctica sobre la salud bucodental. Diseño y análisis de tareas [The development of competence in science in a teaching unit on oral health. Design and analysis of activities]. *Enseñanza de las Ciencias*, 32 (3), 649-667. doi: 10.5565/rev/ensciencias.1346.
- Furió, C., Vilches, A., Guisasola, J., & Romo, V. (2001). Finalidades de la enseñanza de las ciencias en la Secundaria Obligatoria. Alfabetización científica o preparación propedéutica? [Objectives of science teaching in compulsory secondary education. Scientific literacy or propaedeutic training?]. *Enseñanza de las Ciencias*, 19 (3), 365-376.
- García-Carmona, A., Vázquez, Á., & Manassero, M. A. (2012). Comprensión de los estudiantes sobre naturaleza de la ciencia: análisis del estado actual de la cuestión y perspectivas [Students' understanding of the nature of science: analysis of the state of the art and perspectives]. *Enseñanza de las Ciencias*, 30 (1), 23-34.
- García-Ruiz, R., & Castro, A. (2012). La formación permanente del profesorado basada en competencias. Estudio exploratorio de la percepción del profesorado de Educación Infantil y Primaria [Permanent competence-based teacher training. Exploratory study of kindergarten and primary teachers' perceptions]. *Educatio siglo XXI*, 30 (1), 297-322.
- Gil, D., & Vilches, A. (2006). Cómo puede contribuir el proyecto PISA a la mejora de la enseñanza de las ciencias (y de otras áreas de conocimiento)? [How can the PISA project contribute to improving teaching in science (and other knowledge areas)?] *Revista de Educación, Special issue*, 295-311.
- Gordon, J., Halász, G., Krawczyk, M., Leney, T., Michel, A., Pepper, D., & Wiśniewski, J. (2009). *Key competences in Europe: Opening doors for lifelong learners across the school curriculum and teacher education*. Warsaw, Poland: Center for Social and Economic Research (CASE). Retrieved 29/05/2016, from http://www.case-research.eu/upload/publikacja_plik/27191519_CNR_87_final.pdf
- Grandy, R., & Duschl, R. A. (2007). Reconsidering the character and role of inquiry in school science: Analysis of a conference. *Science & Education*, 16, 141-166. doi: 10.1007/s11191-005-2865-z.
- Halász, G., & Michel, A. (2011). Key competences in Europe: Interpretation, policy formulation and implementation. *European Journal of Education*, 46 (3), 289-306. doi: 10.1111/j.1465-3435.2011.01491.x
- Haney, J. J., Czerniak, C. M., & Lumpe, A. T. (1996). Teacher beliefs and intentions regarding the implementation of science education reform strands. *Journal of Research in Science Teaching*, 33 (9), 971-993. DOI: 0022-4308/96/09097 1-23.
- Hargreaves, A. (2003). *Teaching in the knowledge society: Education in the age of insecurity*. New York, U.S.A.: Teachers College Press.
- Honey, M., Pearson, G., & Schweingruber, H. (Eds.) (2014). *STEM Integration in K-12 Education: Status, prospects and an agenda for research*. Washington, U.S.A.: The National Academies Press.
- Jeppsson, F., Haglund, J., & Strömdahl, H. (2011). Exploiting language in teaching of entropy. *Journal of Baltic Science Education*, 10 (1), 27-35.
- Kelchtermans, G. (2005). Teachers' emotions in educational reforms: Self-understanding, vulnerable commitment and micropolitical literacy. *Teaching and Teacher Education*, 21 (8), 995-1006. doi:10.1016/j.tate.2005.06.009.
- Ko, A. C. C., & Lee, J. C. K. (2003). Teachers' perceptions of teaching environmental issues within the science curriculum: A Hong Kong perspective. *Journal of Science Education and Technology*, 12 (3), 187-204. doi: 1059-0145/03/0900-0187/0.
- Köksal, M. S., & Şahin, C. T. (2014). Understandings of advanced students on nature of science and their motivational status to learn nature of science: a Turkish Case. *Journal of Baltic Science Education*, 13 (1), 46-58.
- Lamanauskas, V., & Augienė, D. (2009). Pupils' scientific research activity development in comprehensive school: The case of Lithuania. *Journal of Baltic Science Education*, 8 (2), 97-109.
- Lee, H., Abd El Khalick, F., & Choi, K. (2006). Korean science teachers' perceptions of the introduction of socio scientific issues into the science curriculum. *Canadian Journal of Science, Mathematics and Technology Education*, 6 (2), 97-117. doi: 10.1080/14926150609556691.
- Ley Orgánica Educativa 2/2006, de 3 de mayo, de Educación, LOE [Organic Education Law 2/2006, 3rd May, of Education]. *Boletín Oficial del Estado*, 4th May 2006. Madrid, Spain, MECED.
- Ley Orgánica 8/2013, de 9 de diciembre, para la Mejora de la Calidad Educativa, LOMCE [LOMCE, Organic Law 8/2013, 9th December, for Improving the Quality of Education]. *Boletín Oficial del Estado*, 10th December 2013. Madrid, Spain: MECED.
- Lleixà, T., González-Arévalo, C. & Braz-Vieira, M. (2016). Integrating key competences in school physical education programmes. *European Physical Education Review*, 22, 1-20. doi:10.1177/1356336X15621497.
- López Ruiz, J. I. (2011). Un giro copernicano en la enseñanza universitaria: formación por competencias [A Copernican turn in university education: Competence-based training]. *Revista de Educación*, 356, 279-301.
- Looney, J., & Michel, A. (2014). *Keyconet's conclusions and recommendations for strengthening key competence development in policy and practice. Final report*. Brussels: European Schoolnet. Retrieved 29/05/2016, from http://www.nonio.uminho.pt/keyconet/KeyCoNet%20Final%20Report_FINAL.pdf



- Martín Gámez, C., Prieto, T., & Lupión, T. (2014). Profesorado de ciencias en formación inicial ante la enseñanza y el aprendizaje de las ciencias: ¿perfil innovador o tradicional? [Science teachers in initial training faced with the teaching and learning of sciences: Innovative or traditional profile?]. *Revista Electrónica Interuniversitaria de Formación del Profesorado*, 17 (1), 149-163. doi: <http://dx.doi.org/10.6018/reifop.17.1.180811>.
- Martín Gámez, C., Prieto, T., & Jiménez, A. (2015). Tendencias del profesorado de ciencias en formación inicial sobre las estrategias metodológicas en la enseñanza de las ciencias. Estudio de un caso en Málaga [Tendencias of science teachers in initial training as regards methodological strategies in science teaching. A case study in Malaga]. *Enseñanza de las Ciencias*, 33 (1), 167-184. doi: 10.5565/rev/ensciencias.1500.
- Martínez Galáz, C. P., & González Weil, C. U. (2014). Concepciones del profesorado universitario acerca de la ciencia y su aprendizaje y cómo abordan la promoción de competencias científicas en la formación de futuros profesores de Biología [University teachers' conceptions about science and how to learn it, and how they address the acquisition of scientific literacy when training future biology teachers]. *Enseñanza de las Ciencias*, 32 (1), 51-81.
- Mateos, A., & Ruiz-Gallardo, J. R. (2016). Mejorar la formación en didáctica de las ciencias de los futuros y futuras docentes. Hacia una revisión de su perfil y de las prioridades formativas [Improving teacher training in sciences for future teachers. Towards a revision of their profile and training priorities]. In A. Mateos & A. Manzanares (Eds.). *Mejores maestros, mejores educadores [Better teachers, better educators]* (pp. 237-262). Malaga, Spain: Aljibe.
- McCormick, J., Ayres, P. L., & Beechey, B. (2006) Teaching self efficacy, stress and coping in a major curriculum reform: Applying theory to context. *Journal of Educational Administration*, 44 (1), 53-70. doi: <http://dx.doi.org/10.1108/09578230610642656>.
- Méndez-Giménez, A., Sierra-Arizmendiarieta, B., & Mañana-Rodríguez, J. (2013). Percepciones y creencias de los docentes de primaria del Principado de Asturias sobre las competencias básicas [Perceptions and beliefs of primary teachers in Asturias regarding key competences]. *Revista de Educación*, 362, 737-761. DOI: 10.4438/1988-592X-RE-2013-362-248.
- Méndez-Alonso, D., Méndez-Giménez, A., & Fernández-Río, F. J. (2015). Análisis y valoración del proceso de incorporación de las Competencias Básicas en Educación Primaria [Analysis and assessment of the process incorporating Basic Skills in Primary Education]. *Revista de Investigación Educativa*, 33 (1), 233-246. doi: <http://dx.doi.org/10.6018/rie.33.1.183841>.
- Mendoza, F., & Rodríguez-Pineda, D. (2009). La educación por competencias en ciencias naturales [Competence-based education in natural sciences]. *Enseñanza de las Ciencias, Special issue*, 3525-3529.
- Michaels, S., Shouse, A. W., & Schweingruber, H. A. (2007). *Ready, Set, Science! Putting Research to Work in K-8 Science Classrooms*. Washington, DC, U.S.A.: The National Academies Press.
- Ministerio de Educación, Cultura y Deportes-MECD [Ministry of Education, Culture and Sport] (2015). *Enseñanzas no universitarias. Estadística del profesorado y otro personal [Non-university education. Statistics on teachers and other staff]*. Madrid, Spain: MECED. Retrieved 29/05/2016 from <http://www.mecd.gob.es/servicios-al-ciudadano-mecd/estadisticas/educacion/no-universitaria/profesorado/estadistica.html>.
- Monarca, H., & Rappoport, S. (2013). Investigación sobre los procesos de cambio educativo: El caso de las competencias básicas en España [Research into the processes of educational change: The case of key competences in Spain]. *Revista de Educación, Special issue*, 54-78. doi: 10.4438/1988-592X-RE-2013-EXT-256.
- Organisation for Economic Co-operation and Development (OECD) (2002). *Definition and selection of competences (DeSeCo): Theoretical and conceptual foundations. Strategy paper*. Retrieved 29/05/2016, from <http://www.deseco.admin.ch/bfs/deseeco/en/index/02.parsys.34116.downloadList.87902.DownloadFile.tmp/oecdesecestategypaperdeelsaedcericd20029.pdf>.
- Organisation for Economic Co-operation and Development (OECD) (2005). *The definition and selection of key competences. Executive summary*. Retrieved 29/05/2016, from <https://www.oecd.org/pisa/35070367.pdf>.
- Organisation for Economic Co-operation and Development (OECD) (2007). *El programa PISA de la OECD. Qué es y para qué sirve [The OECD's PISA programme: What is it and what is it for?]*. Paris, France: OECD. Retrieved 29/05/2016, from <http://www.oecd.org/pisa/39730818.pdf>
- Özdem, Y., Çavaş, P., Çavaş, B., Çakiroğlu, J., & Ertepinar, H. (2010). An Investigation of elementary students' scientific literacy levels. *Journal of Baltic Science Education*, 9 (1) 6-19.
- Partnership for 21st century learning (2015). *P21 Framework Definitions*. Retrieved 29/05/2016, from http://www.p21.org/storage/documents/docs/P21_Framework_Definitions_New_Logo_2015.pdf
- Pedrinaci, E., Caamaño, A., Cañal, P., & Pro, A. (2012). La evaluación de la competencia científica requiere nuevas formas de evaluar los aprendizajes [The assessment of competence in science calls for new ways of evaluating learning]. In E. Pedrinaci (Eds.). *11 ideas clave: El desarrollo de la competencia científica [11 key ideas: The development of competence in science]* (pp. 241-267). Barcelona, Spain: Graó.
- Pedrinaci, E. (2013). Alfabetización en Ciencias de la Tierra y competencia científica [Literacy in Earth Sciences and competence in science]. *Enseñanza de las Ciencias de la Tierra*, 21 (2), 208-214.
- Pro, A., & Nortes, R. M., (2016). ¿Qué pensaban los estudiantes de la diplomatura de maestro de educación primaria sobre las clases de ciencias de sus prácticas de enseñanza? [What did students on the primary teacher degree course think of the science lessons on their teaching practice?]. *Enseñanza de las Ciencias*, 34 (1), 7-32. doi: 10.5565/rev/ensciencias.1762.
- Roehrig, G. H., Kruse, R. A., & Kern, A. (2007). Teacher and school characteristics and their influence on curriculum implementation. *Journal of Research in Science Teaching*, 44 (7), 883-907. Doi: 10.1002/tea.20180.
- Sanmartí, N. (2010). Competencias: ¿más burocracia o un constructo útil? [Competences: More bureaucracy or a useful construct?]. In J. Vallès, D. Álvarez & R. Rickenmann (Eds.). *L'activitat docent. Intervenció, innovació, investigació [Teaching: intervention, innovation, research]* (pp. 51-66). Girona, Spain: Documenta Universitaria.



- Schweingruber, H., Keller, T., & Quinn, H. (Eds.) (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. National Research Council. Committee on a Conceptual Framework for New K-12 Science Education Standards. Washington, D.C., U.S.A.: The National Academic Press.
- Sharp, J. G., Hopkin, R., & Lewthwaite, B. (2011). Teacher perceptions of science in the national curriculum: Findings from an application of the Science Curriculum Implementation Questionnaire in English primary schools. *International Journal of Science Education*, 33 (17), 2407-2436. doi: 10.1080/09500693.2010.550698.
- Sierra-Arizmendiarieta, B., Méndez-Giménez, A., & Mañana-Rodríguez, J. (2013). La programación por competencias básicas: hacia un cambio metodológico interdisciplinar [Planning by key competences: towards an interdisciplinary methodological change]. *Revista Complutense de Educación*, 24 (1), 165-184. doi: http://dx.doi.org/10.5209/rev_RCED.2013.v24.n1.41196.
- Vilches, A., & Gil, D. (2010). El programa PISA: un instrumento para la mejora del proceso de enseñanza-aprendizaje [The PISA programme: an instrument for improving the teaching-learning process]. *Revista Iberoamericana de Educación*, 53, 121-154.
- Wellington, J., & Osborne, J. (2001). *Language and Literacy in Science Education*. Buckingham, Philadelphia, U.S.A.: Open University Press.
- Yore, L. D., & Treagust, D. F. (2006). Current realities and future possibilities: Language and science literacy - empowering research and informing instruction. *International Journal of Science Education*, 28 (2-3), 291-314. doi: 10.1080/09500690500336973.

Received: April 28, 2016

Accepted: June 22, 2016

Antonio Mateos Jiménez

PhD., Professor, Science Education (Department of Pedagogy), Faculty of Education of Toledo, University of Castilla-La Mancha, Edificio Sabatini, Despacho 1.31. Campus Tecnológico de la Fábrica de Armas. Avda. Carlos III s/n. 45071. Toledo, Spain.
E-mail: Antonio.Mateos@uclm.es

Beatriz García Fernández
(Corresponding author)

PhD., Professor, Science Education (Department of Pedagogy), Faculty of Education of Ciudad Real, University of Castilla-La Mancha, Ronda de Calatrava, 3. 13071, Ciudad Real, Spain.
E-mail: Beatriz.Garcia@uclm.es

María Teresa Bejarano Franco

PhD., Professor, Department of Pedagogy, Faculty of Education of Ciudad Real, University of Castilla-La Mancha, Ronda de Calatrava, 3. 13071, Ciudad Real, Spain.
E-mail: MariaTeresa.Bejarano@uclm.es

