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# Sciences Teachers who Reflect their Teaching: Developing the PCK of Evolution and Nature of science

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## Abstract

*Changing the teaching practice is a complex task for science teachers, especially if they are not aware about their Pedagogical Content Knowledge (PCK). This knowledge described by Shulman (1986) is one of the most difficult to represent and understand by teachers. Accordingly, this research explores the modification in the PCK specifically of Evolution and Nature of Science (NoS) by two biology teachers who participated in a professional development programme (PDP) with a following up in the classroom. The entire programme was held during 6 months with different activities such as revisit concepts, joint planning, and delivery of a planned lesson. Data was collected through semi-structured interviews to identify initial and final Content Representation (CoRe) of the teachers for both Evolution and NoS and their Professional and Pedagogical experience Repertoire (PaPeRs) regarding to the Loughran et al model (Loughran, Mulhall, & Berry, 2004). The data analysis was made by the participants and the researchers trying to recognise the teacher's PCK, its modification and the reasons behind their actions. The findings show that the teachers changed their beliefs and knowledge about the best way to teach and learn Evolution through NoS. Furthermore, they realised that those changes are related to the review of their own practice. The discussion was centred on the modifications of the teacher's PCK in both contents. The advantages and possibilities that the representation of the PCK in terms of CoRe and PaPeRs model (Loughran, Mulhall, & Berry, 2004) were discussed as well. The implications of this work are related to how we can incorporate PCK, in a PDP, in order to improve the teaching of Evolution and NoS.*

## 1. Introduction

Pedagogical content knowledge (PCK) is the most widely used theoretical constructs in the last decades for pre-service and in-service teacher training around the world (Shulman 1986; Park & Oliver 2008; Loughran et al., 2012). Researchers agree on the nature of PCK as an integration of knowledge and beliefs, acquired through teaching and used in the context of teaching a specific content (Loughran et al. 2004; Magnusson et al. 1999). It has been suggested that PDP that consider teachers' PCK may further improve this knowledge (Loughran et al. 2012). In the issue of understanding and teaching Evolution Theory there exists a lot of work about the assessment of knowledge and acceptance of biology teachers (Nehm et al. 2009). Yet little attention has been paid to the teachers' PCK in evolution, and how to develop it or how this could be related to another important issue in teaching evolution: Nature of Science.

### 1.2 Research Questions

The following research questions establishing the direction of the research:

- How is the change on the PCK of Evolution and NoS in two Biology teachers who participated in a PDP?
- What can we expect of the teaching of Evolution through NoS?

## 2. Methods

We used a mixed-methods research approach and a multiple case of study design to investigate the impact of the PDP on in-service biology teachers' PCK of Evolution and NoS. The entire programme was held during 6 months with different activities such as revisit concepts, joint planning, and delivery of a planned lesson. After the experience, teacher's lessons were video recorded and analysed to

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identify strategies, activities and conditions, related to the learning of the students about Evolution and NoS.
Data was collected through semi-structured interviews to identify initial and final Content Representation (CoRe) of the teachers for both Evolution and NoS and their Professional and Pedagogical Experience Repertoire (PaPeRs) regarding the Loughran et al model (Loughran, et al, 2004). The final interview was a stimulated recall interview (SRI) with the extracts of the recorded lessons, trying to identify the PCK of these teachers, its modifications and the reasons behind their actions. The data analysis was made by the participants and the researchers trying to recognise the teacher's PCK. The analysis was performed comparing the pre and post interviews using Atlas-ti.

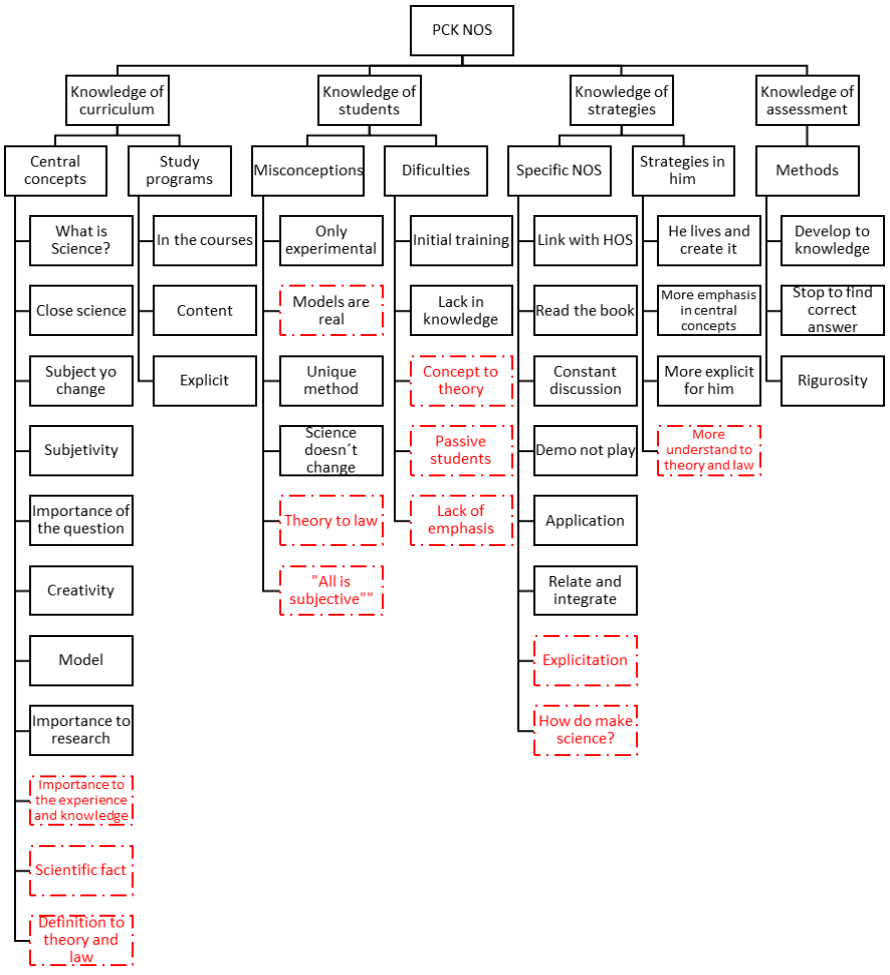
## 3. Results

### 3.1 Changes/Develop Biology Teachers´ PCK in Evolution and NoS

The knowledge of the teaching of Evolution and NoS of these two teachers was changed. The components of PCK described by Magnusson et al. (1999) showed modifications in terms of knowledge of curriculum, students, strategies and assessment for both contents. See figures 1 and 2 as examples of the changes in NoS with each teacher. These PCK diagrams show the moment after the PDP based on the first CoRe interview (black and continuous boxes), and at the end of the following up in the classroom part of the professional development program based on final Core interview and the stimulated recall (red and discontinuous boxes).

*PCK de NoS: Peter*

After delivering the lessons this teacher, incorporates new central ideas as recognising the importance of experience and prior knowledge, related to the fact that science is subjective, the relevance of scientific fact and the difference between theory and law. This last one central idea is recognised as the most Important link between NoS and evolution. Related to this he realises that a misconception that appears in the students is theories can become laws, however, he acknowledges that he understands this difference more and that the way to overthrow it is to work how science is done. As strategies recognise that above all in the teaching of NoS is important to explain the aspects, that would allow, for example, to understand how powerful and robust a theory can be. Finally, he recognises as limitations the understanding that students have the concept of theory and in terms of his practice, he realises that he leaves little room for students to respond and that in some subjects he gave little emphasis.



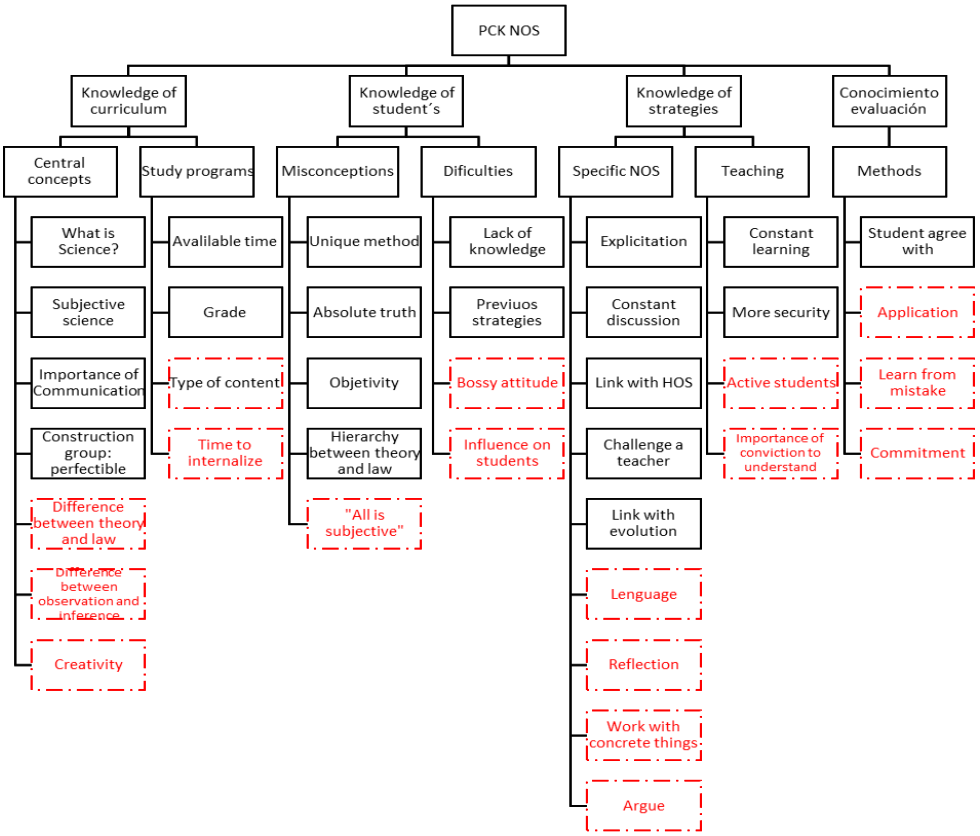



Fig 1. Peter's PCK of evolution and its changes.
Fig 2. Annie's PCK of NoS and its changes.

*PCK Nature of science: Annie*

After the lessons, Annie incorporates new central ideas such as the importance to work the difference between theory and law and between observation and inference, as well as the aspect of creativity in scientific work. She recognises as a new misconception that the students for all questions give the same answer that "*everything is subjective*", then they now use subjectivity as a "bonus track". She thinks that one of the ways to work on this preconception is to use the argumentation of answers and work with concrete things as a strategy. Other strategies she proposes is that there should be more reflection on the part of the students and must be precise in the language that occupies since she realised that she can influence her students to have misconceptions. She recognises that it takes more time to internalise these aspects, that is to say, a reorganization of the curriculum is proposed, in addition, she thinks that the type of content to treat aspects of NoS is no longer limiting, on the contrary, she can treat these aspects associated with any content and at any school level. She believes that a greater understanding of the aspects of NoS is given by a greater conviction of these, in this way she learned these aspects and in her students could be similar, if we consider more time to internalise and more space for reflection.

### 3.2 Teaching evolution through NoS

In terms of the teaching of evolution and the relation with the teaching of Nature of science, both teachers recognised the relevance of using NoS for teaching Evolution. The following Professional and Pedagogical Experience Repertoire is related to that:

*PaPeR: Relation between Evolution and NoS*

The teacher Annie recognised that to make the relation between evolution and NoS improved the understanding of evolution. In this sense, she believes that the first class with NoS without context help the students to work NoS's aspects such as theory and law, subjectivity and models in science.

The teacher Peter also recognised the importance of this link. However, he is aware that in the future he needs to make more explicit this relationship, for example, talking more about theory and hypothesis and how the different phylogenetic tree is a hypothesis.

## 4. Discussion and conclusion

Some research suggests that the teaching of the theory of Evolution linked to the teaching of Nature of Science could help the understanding and acceptance of the first (Cofré et al., 2013). The two teachers also recognise the importance of this link, especially in the first class they perform where NoS works without content. Nevertheless, they consider that they lacked to make more explicit the link that they intended to do between Evolution and NOS. This is related to what is described by Mellado et al (2007) that the teaching of NoS should be done explicitly so that their understanding can be achieved. Thus, in this case, understanding NoS would be a first step in understanding evolutionary theory. These teachers mention that they should teach aspects of NoS explicitly from early levels of science teaching since the understanding of NoS influences the acceptance of evolution (Großschedl, Konnemann, & Basel, 2014). One of the explicit links that teachers make to the acceptance and understanding of the theory of evolution is the deepening of NoS aspects related to the nature of theories (what they are and how they are) and the importance of speaking of scientific fact or evidence. While one of the teachers acknowledges that the last aspect of his lesson worked, he said that he needed to give more space to the discussion of research and evidence that give strength to theories. This is consistent with what Lombrozo et al. (2008) state that an important issue is to understand some aspects of NoS such as "theories are reliable and reliable but still provisional" (p. 296) to accept the theory of evolution. They also recognise that the type of questions they ask may induce the type of responses that students give, which is in line with Kampourakis (2014) that the "why" questions might imply the existence of an end or objective, as what happened to teachers when they received in response that the change in evolution was out of necessity.

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