

Teachers' views on understanding evolutionary theory: A PCK-study in the framework of the ERTE-model

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ABSTRACT

The study of Pedagogical Content Knowledge (PCK) that is presented in this paper aims to obtain an impression of teachers' knowledge and beliefs concerning teaching evolutionary theory. The starting point of this project was the development of the Educational Reconstruction for Teacher Education model (ERTE). The PCK-study shows that teachers' attitudes toward students' conceptions of evolutionary theory are not always constructive and that teachers often lack awareness of the historical nature of biology. Scenario questions proved to be effective interview items in order to acquire a detailed picture of teachers' ways to react to students' pre-scientific conceptions.

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1. Introduction

Evolutionary theory is central to biology and a thorough understanding of evolution is a prerequisite for participating in almost any debate regarding biological themes. But the theory of evolution is also a complex theory about which a great variety of conceptions exist among the general public. Secondary school teaching aims to guide the development of the students' pre-scientific conceptions toward the scientific viewpoint. The experience-based ideas about evolution with which students enter the teaching process form the bases for this developmental process. However, research has shown that students often leave the learning process without having acquired a scientifically valid conceptual framework of evolutionary theory (Alters & Nelson, 2002).

That knowledge of the students' topic specific pre-scientific conceptions is important for science teaching is widely recognized in the field of educational research and much research has already been undertaken to uncover and describe these pre-scientific conceptions. Additionally, it is also important for science teaching to study the knowledge and beliefs that teachers have. Van Driel, Verloop, and De Vos (1998) observed that there is a lack of studies on science teachers' topic specific Pedagogical Content Knowledge (PCK). Furthermore, they suggested that such PCK studies could benefit from incorporating research on student learning. The literature on students' conceptions concerning evolutionary theory

should therefore be complemented by studies on the same topic from the teachers' perspective.

The PCK-study that is presented in this paper is based on the assumption that experienced teachers have developed their PCK with respect to the topic of evolutionary theory in their teaching practice and that this knowledge is worth exploring. The aim of this study is to obtain an impression of teachers' knowledge and beliefs¹ concerning the teaching of evolutionary theory. The starting point of the project was the development of a research model for the study of PCK, the Educational Reconstruction for Teacher Education model (ERTE), which was published in a previous issue of *Teaching and Teacher Education* (Van Dijk & Kattmann, 2007). This previous paper also includes a discussion of the history, the nature and the sources of the concept of PCK. The study of teachers' PCK on evolutionary theory, which is presented in this second paper, is the first empirical study in the framework of the ERTE-model. This qualitative study can be seen as a first step toward the development of a mixed method approach to the study of PCK. The ERTE-model is based on an established research model, the model of Educational Reconstruction (ER). This ER-model was developed for the design of learning environments based on a critical analysis of the subject matter in relation to an empirical study of students' pre-scientific conceptions (Duit, Gropengießer, & Kattmann, 2005). A short description of the ERTE-model will be presented in Section 3.

¹ I use the phrase "knowledge and belief" because it is difficult to make a distinction between knowledge – defined as justified beliefs – and beliefs (see also Fenstermacher, 1993).

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The PCK-study provides an overview of the teachers' knowledge of students' problems with understanding evolutionary theory and provides information on teachers' attitudes toward students' pre-scientific conceptions. The PCK-study shows that teachers' attitudes toward students' conceptions of evolutionary theory are not always constructive, that is they do not always help teachers to address students' learning problems adequately. The study further shows that teachers display a variety of conceptions concerning the nature of science (NOS) and that teachers often lack awareness of the historical nature of biology. The evaluation of the PCK-study suggests that scenario questions are the most effective interview items in order to acquire a detailed picture of teachers' ways to react to students' problems concerning evolutionary theory. In Section 4 the methodology of the study is described. In Section 5 the findings of the PCK-study are presented followed by a presentation of the conclusions and an outlook in Section 6. But first a short description of the nature and sources of PCK is presented in Section 2.

2. Pedagogical Content Knowledge

There is no universally accepted conceptualization of what exactly PCK is. Shulman introduced PCK as a concept that represents:

[T]he blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction (Shulman, 1987, p. 8).

PCK concerns the teaching of specific topics, and is therefore to be discerned from general knowledge of pedagogy and subject matter knowledge. The 'PCK' concept is a tool for studying certain aspects of teacher knowledge. PCK refers to a teachers' personal and private knowledge, but PCK cannot be seen to be a real separate knowledge domain in the human mind. Rather, it is a heuristic device for thinking about teacher knowledge (Borko & Putnam, 1996).

All scholars seem to agree with Shulman (1987) that the understanding of students' specific learning difficulties and the knowledge of subject matter representations to overcome these difficulties are two essential elements of PCK (Van Driel et al., 1998). The phrase 'subject matter representation' does not only refer to textbook examples. It also refers to analogies and metaphors that teachers use to clarify difficult points. As this study will show, teachers often react to students' problems concerning adaptation by using briefly formulated analogies to illustrate where, according to the teacher, the students are going wrong. The two related elements of PCK, knowledge of students' pre-scientific conceptions and subject matter representations, enable teachers to anticipate students' problems with respect to a specific topic and to react in appropriate ways. Additionally, teachers have to be able to handle the complexities of their daily teaching practice flexibly: They have to be able to analyse the value of different textbook examples in relation to a specific topic and they have to be able to follow the various ideas that students express. This requires teachers not only to have adequate knowledge of the subject matter, they also have to be able to use this subject matter knowledge in their teaching (Ball & Bass, 2000). Therefore, a third element of PCK is distinguished: This element of PCK, which is simply called 'subject matter knowledge for teaching', enables the teacher to react adequately in different and unanticipated situations.²

² 'Subject matter knowledge for teaching' is comparable with what Ball and Bass (2000, p. 89) describe as 'pedagogical useful mathematical understanding'. The main difference with the conceptualization of teacher knowledge presented here is that according to the view of Ball and Bass (2000) this knowledge is not included in PCK. However, I suggest that 'subject matter knowledge for teaching' consists of a blending of content and pedagogy and should therefore be included in PCK.

A review of the literature on science teachers' PCK shows that, although the amount of research is limited, the results of the existing studies are consistent: "Although teachers have some knowledge about students' difficulties, they commonly lack important knowledge necessary to help students overcome those difficulties" (Magnusson, Krajcik, & Borko, 1999, p. 106). Studies of teachers' PCK indicate further that subject matter knowledge is a prerequisite for the development of PCK and that PCK develops in the actual teaching practice of teachers (Grossman, 1990; Van Driel et al., 1998). Additionally, these studies indicate that specific courses or workshops have the potential to influence the development of PCK.

3. The model of educational reconstruction for teacher education

The main purpose of the study described in this paper is to formulate recommendations for teacher education with respect to the teaching of evolution. Teacher training is necessary for novice and experienced teachers to develop their PCK in their teaching practice; it enables the teachers to learn from their experiences (Grossman, 1990; Van Driel et al., 1998).

The study of teachers' PCK on evolutionary theory aims to answer the following three research questions (RQ):

- (RQ1) What 'subject matter knowledge for teaching' do biology teachers have concerning the topic of evolutionary theory?
- (RQ2) What knowledge and beliefs do biology teachers have of students' pre-scientific conceptions with respect to evolutionary theory?
- (RQ3) What knowledge and beliefs do biology teachers have of subject matter representations regarding the theory of evolution?

The ERTE-model provides the framework for an integrative approach of the study of teachers' PCK. The ERTE-model aims to make explicit how the different elements influence each other mutually (Fig. 1). For example, the empirical PCK-study provides knowledge on students' difficulties with understanding adaptation and the misconceptions literature influences the development of the interview protocol for the PCK-study. The model can be used to explore teachers' knowledge and beliefs about (1) the 'subject matter for teaching', (2) students' pre-scientific conceptions, and (3) representations of the subject matter, in relation to the empirical literature on (a) learning environments, (b) students'

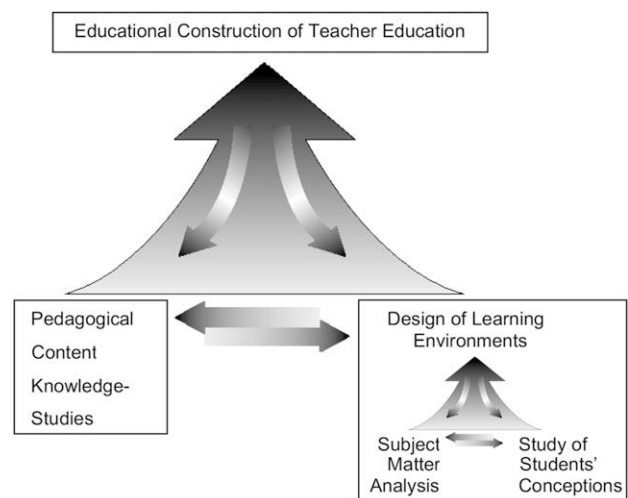


Fig. 1. The model of educational reconstruction for teacher education.

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