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► **To cite this version:**

Isabelle Kermen. Investigating pedagogical content knowledge of teachers faced with a new curriculum on the evolution of chemical systems. ESERA conference, Aug 2007, Malmö, Sweden. pp.131-138. hal-02883039

HAL Id: hal-02883039

<https://hal.science/hal-02883039>

Submitted on 28 Jun 2020

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Investigating pedagogical content knowledge of teachers faced with a new curriculum on the evolution of chemical systems

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Oral presentation

Abstract:

A curriculum on the evolution of chemical systems was recently implemented in the final year of Higher Secondary Education in France. An epistemological analysis of the content of the curriculum and an analysis of the effects of teaching on students' conceptual development were made, in order to investigate the PCK teachers have developed when teaching this curriculum. In this communication we focus on the students' learning difficulties and errors teachers recognize or do not. We carried out semi-structured interviews including the presentation of authentic students' responses. Teachers are aware of several students' learning difficulties or errors they make, but they are not numerous to stress the difficulties students may have to revise their conceptions on chemical change to understand the chemical equilibrium concept. The presentation of students' responses (a) helps a teacher to develop his PCK in finding out that some students make errors that he was not aware of (b) reveals that some teachers have difficulties themselves. These difficulties concern more particularly the understanding of subjects involved in the models introduced by this curriculum.

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Context

The French chemistry curriculum in the final year of higher secondary education has recently been changed (September 2002). This curriculum introduces the states of chemical systems, the evolution from initial state to equilibrium state, and a systematic procedure to predict and explain the direction of chemical changes by comparing the reaction quotient to the equilibrium constant, which is called 'the evolution criterion'. This thermodynamic approach is combined with a kinetic point of view to stress the dynamic nature of the chemical equilibrium state. This curriculum was quite new for teachers and students alike.

In this paper we present an attempt to investigate some components of the pedagogical content knowledge teachers could elaborate from their teaching practice. What do they know about students' pre-conceptions and learning difficulties?

Theoretical framework

Studies involving the notion of Pedagogical Content Knowledge (PCK) proposed by Schulman (Gess-Newsome and Lederman, 1999) or that of the local professional knowledge (Morge, 2003) seek to develop among teachers specific knowledge for teaching a given subject. Numerous studies demonstrate that PCK was identified as a crucial component of the knowledge necessary for good disciplinary teaching (Baxter and Lederman 1999). Relevant subject matter knowledge is not sufficient for the development of PCK, some teachers with a high level of disciplinary knowledge show themselves incapable of helping their students to acquire it (Magnusson, Krajcik and Borko, 1999). Among other knowledge such as pedagogical knowledge, subject matter knowledge and students' learning difficulties knowledge are part of PCK and contribute to transform the knowledge to be taught into a form that is understandable by students (Geddis, 1993; De Jong, 1998; Bond-Robinson, 2005).

Research questions

Our entire PhD research includes three main parts. In the first one, we developed an epistemological analysis of the content of the curriculum highlighting the underlying models and their links with empirical facts (Kermen, 2005a). In a second one, we investigated the effects of teaching on students' conceptual development, particularly the students' use of thermodynamic and kinetic models and alternative conceptions of evolution of chemical systems (Kermen and Méheut, 2004; Kermen, 2005b) by mean of questionnaires. In the third part which deals with the PCK teachers have developed when teaching this curriculum, we determine if subjects emphasized by our content analysis are considered as issues by the teachers and if they are aware of the students' learning difficulties. Our purpose is to provide some relevant directions to devise teacher training activities.

In this communication we focus on the students' learning difficulties and errors the teachers recognize or do not. The research questions are as follows:

Are the teachers conscious of the students' learning difficulties related to the evolution of chemical systems?

What can be the impact of presenting to teachers students' productions revealing learning difficulties?

Methodology

We carried out semi-structured interviews of teachers. As Van Driel, Verloop and De Vos (1998) used authentic student responses to make teachers aware of the students' difficulties in a workshop, we asked teachers to examine students' responses in order to determine which errors the teachers point out. The interview protocol is made of two parts: the first part begins with two general questions, what difficulties the students have in the second part of the curriculum, do they make typical errors? Then some more precise questions are asked about students' learning difficulties we derived from our previous study regarding the students. In the second part of the interview students' responses are presented to teachers one by one. Each student's response includes at least an error revealing a specific difficulty.

Several chemistry and physics¹ teachers (15) were interviewed. All of them had 5 years - or more, up to 30 years- of experience in teaching chemistry in higher secondary education.

Results

In this table we list the students' learning difficulties stemming from our analysis – with the numbers of teachers who actually quoted them– and the errors that students can make – with the numbers of teachers who quoted them during the first part of the interview or identified them in the students' responses they were faced to in the second part of the interview.

difficulties		quoted	associated errors		quoted	identified
to understand the difference between a complete change and an incomplete change	D1	6	the final extent of reaction is always equal to the maximal extent	E1	1	
to admit that a chemical change can occur in the reverse direction of the chemical equation	D2	5	the direction of evolution is always the direct one	E2	3	1
to write the reaction quotient formula	D3	0	modification of the reaction quotient formula	E3	0	13
			to write the concentration of a solid or of the solvent in the reaction quotient formula	E4	8	
to explain why an incomplete chemical change stops	D4	11	no reaction quotient calculation to prove that system is at equilibrium	E5	0	11
to imagine that two opposing reactions occur simultaneously	D5	1	two opposing reactions occur successively	E6	0	10
to understand the distinction between change and reaction	D6	11	to use a word for another	E7	3	6
			to say the chemical change does not stop	E8	0	5
to consider a chemical reaction as a macroscopic concept	D7	0	to say a chemical reaction is a microscopic concept	E9	0	0

On the teachers' awareness of the students' learning difficulties related to the evolution of chemical systems.

We listed seven difficulties and the associated errors. Two of them (D5, D7) are not quoted by teachers. The other students' learning difficulties or the associated errors are mentioned in reply to a specific question (E4, D4, D6) or spontaneously by teachers (D1, D2).

Teachers are aware of some students' learning difficulties or errors they make, but seem to be not aware of others.

On the impact of the presentation of student responses

Three different cases are considered. In the first case, teachers do not say that students have any difficulty with a specific matter or make any error related to this matter but recognize an error which can be associated to this difficulty (D3-E3, D5-E6).

¹ In France chemistry and physics are taught by the same teacher who is qualified in both subjects.

In the second case teachers announce that students encounter difficulties with a specific matter but do not point out an error linked to this difficulty or are not very numerous to do it (D2-E2, D6-E7, D6-E8).

In the third case teachers do not mention any difficulty on a specific matter and do not identify an associated error (D7-E9).

In these two last cases the presentation of students' responses allows us to determine what difficulties teachers actually share with the students. In the first case, it helps the teacher to become aware of a new kind of error that students can make, because he does not share any difficulty with the students about that subject.

Conclusion

Although two points (D1, D2) we listed, have been stressed as required changes in conceptions about chemical changes (Van Driel, De Vos, Verloop, Dekkers, 1998) in order to understand the chemical equilibrium concept, they are not quoted by many teachers.

The presentation of students' responses (a) helps a teacher to develop his PCK in finding out that some students make errors that he was not aware of (b) reveals that some teachers have difficulties themselves. These difficulties concern more particularly the understanding of subjects involved in the models introduced by this curriculum.

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