USING COMMUNICATION PATTERNS FOR ANALYSING CLASSROOM ACTIVITIES IN CHEMISTRY

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Abstract: The presented study is part of the project ProwiN (Professionswissen in den Naturwissenschaften – professional knowledge in science) that explores three dimensions of professional knowledge in science: content knowledge (CK), pedagogical content knowledge (PCK) and pedagogical knowledge (PK) of chemistry teachers. The central aim of this study is to investigate the correlation between PCK and chemistry teachers' classroom activities. For this purpose, a theory-driven category system based on the standards of content analysis is being developed in order to analyse videos of chemistry lessons. This study is predominantly concerned with the analysis of communication patterns between teachers and students. The central aim is to discern how teachers deal with their students' misconceptions. Therefore 25 videos of chemistry lessons available from an earlier video study is analysed with the help of communication process diagrams. Examples of our new developed communication process diagrams as well as results from the first study are presented.

Keywords: pedagogical content knowledge, video category system, classroom activities, students' misconceptions, communication patterns

INTRODUCTION

Both teachers' knowledge and teachers' classroom activities have become focal points in science education research (Baumert, Kunter, Blum, Brunner & Voss et al., 2010; Stigler, Gonzales, Kawanaka, Knoll & Serrano, 1999). One major deficit in chemistry instruction research is seen in the lack of studies that correlate teachers' PCK and teachers' classroom activities (Abell, 2007; Lipowsky, 2006). To that end, advantages of video analysis become obvious. Thus, the main goal of this current study is to develop a video category system in order to evaluate chemistry teachers' PCK while focusing on students' misconceptions.

The main variables that determine successful teaching are (1) the teacher and (2) his or her professional knowledge. Following Shulman's concept of professional knowledge (1987), a theoretical distinction is often drawn between pedagogical knowledge (PK), content knowledge (CK), and the knowledge needed for teaching a specific subject: pedagogical content knowledge (PCK). The presented study is part of the larger project ProwiN that examines these three dimensions of professional knowledge in science, assuming that they influence chemistry instruction and enable us to draw inferences about students' learning outcomes. Although several conceptualisations of PCK have already been developed, there is no generally accepted definition of PCK (Kind, 2009). However, two facets can be seen as key elements of PCK: knowledge of representations and strategies and knowledge of students' misconceptions (Van Dijk & Kattmann, 2010). This study is solely concerned with students'misconceptions/preconceptions.

The interest of scientists in students' ideas and especially in their misconceptions came to prominence at the end of the 1970s and in the early 1980s. Misconceptions mean any concept that differs from the commonly accepted scientific understanding of the concept (Nakhleh, 1992).

The essential purpose of the study is to explore how teachers deal with their students' misconceptions. To do that, communication patterns in the classroom are closely analysed. Pitton (1997) identified typical communication patterns in chemistry lessons: One major pattern is that teachers tend to ask narrow, leading questions and therefore impede qualified statements from their students.

Fundamental to this project are the following research question and hypothesis:

Q1: Is there any difference in terms of communication patterns between chemistry teachers with a high score in the PCK test and those with a low score in the PCK test?

H1: Chemistry teachers with high PCK provide their students more often with the possibility to give reasons for their statements in communication processes than chemistry teachers with a low PCK.

METHODS

For this study, 40 lessons of chemistry teachers will be videotaped. Therefore, a theory-driven category system based on the standards of content analysis is being developed in order to analyse videos of chemistry instruction that focus on students' misconceptions (Bos & Tarnai, 1999). To explore the instructional surface structure (e.g. organisational elements of the lessons) and the deep structure (e.g. teachers' perception of students' misconceptions), low and high inferent categories are designed. Referring to Bos & Tarnai (1999), the development of the coding system can be subdivided in five central steps. On the basis of the theoretical background and research question (step 1), observation categories are identified and category systems are constructed (step 2). These categories are described by an operational definition in a coding manual with rules and indicators referring to both, theory and video data. The categories are repeatedly checked, corrected, and modified. In a further step (step 3) called training session, three coders independently analyse a set of video lessons with the help of the written instruction. There are two ways of realising the video coding process. One method is to watch 10 seconds of the clip, code all variables, and go on with the next 10-second interval (time sampling). In a second type, a clip keeps running until the coder gives an explicit signal to end the coding (event sampling). The coder training in step 3 is completed when the coders reach a direct observer agreement of 60 to 75%. In this study an event based coding is used. Step 4 focuses on the analysis of the data. Finally (step 5), the results are interpreted in reference to the theoretical research questions (Bos & Tarnai, 1999; Janik & Seidel, 2009; Olszewski, 2010; Seidel, Prenzel & Kobarg, 2005). In this study, teachers' PCK is assessed by using a test that has already been developed (Witner & Tepner, 2011).

During the development of the observation tool, a theoretical model (Figure 1) for comprehending the surface and deep structures of instruction is also designed. This model represents concise qualified students' statements:

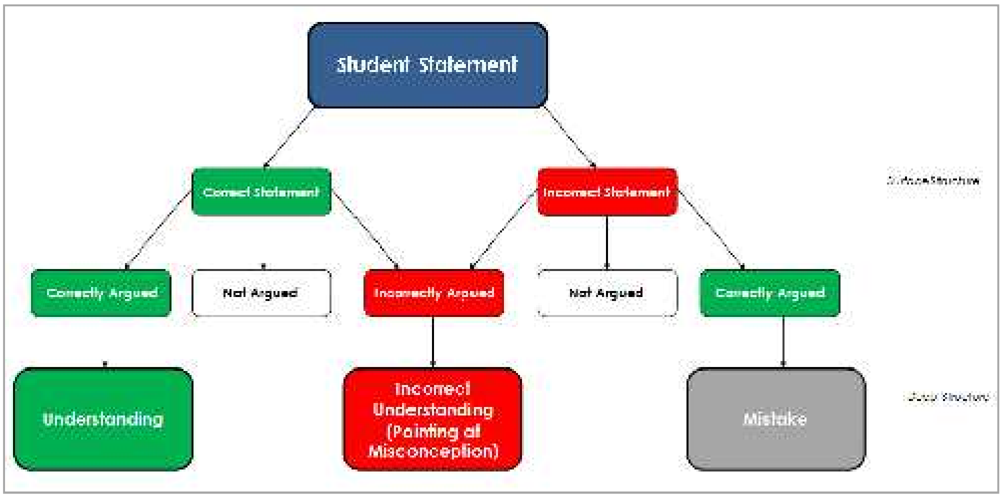

Figure 1. Theoretical Model

To refine this model, video material of 25 chemistry lessons is being analysed with the help of communication process diagrams. The videos belong to two different groups of classes of a grammar school (Gymnasium): One part of the sample (N = 10) consists of 7th grade classes, while the other part (N = 15) consists of 10th grade classes. The video data concentrate on lessons on the topics "state of matter" and "acids, bases, neutralisation". The following diagrams have been designed to evaluate the communication processes in science lessons and, most importantly, to answer how teachers deal with students' statements and misconceptions. Communication patterns in which teachers effectively prompt or ask for reasoned students' statements are important for encouraging students to express their ideas more qualitatively and proactively. Additionally, these patterns are assumed to be a prerequisite for learning about students' misconceptions. The following figure (figure 2) provides observers with a brief overview of a diagrammed lesson:

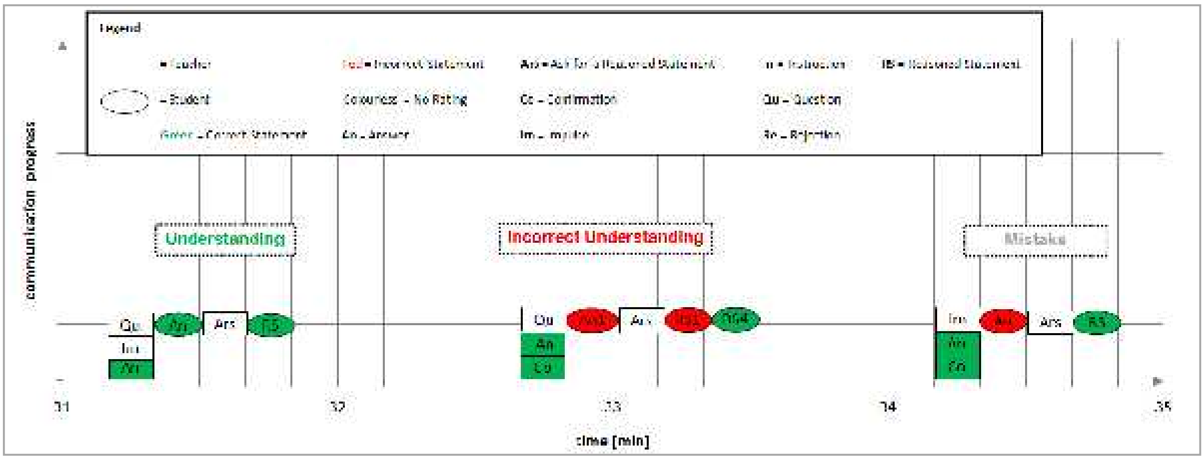

Figure 2. Prototypical Elements of Communication Process Diagrams

The whole communication process diagrams (see Figure 2 for prototypical elements) are developed in a two-dimensional coordinate system with time on the x-axis and communication progress on the y-axis. The prerequisite for using communication process diagrams in the analysis of student-student or teacher-student discussions is a clear definition of the symbols (see shortcuts in the legend). First, there is a distinction between a rectangular symbol for the teacher and the ellipse for the student. The statement of the student or teacher is followed by a specification of the statement: answer (An), ask for reasoned statement (Ars), confirmation (Co), impulse (Im), instruction (In), question (Qu), rejection (Re), and reasoned statement (Rs). The third color-based criterion (green/red) divides between student/teachers' statements which are correct or incorrect from a scientific point of view. With every new scientific statement, the communication progress enters a new level in the diagram. The communication process diagrams show typical communication patterns in a chemistry classroom. In a first step, 25 videos of grammar school chemistry teachers were analysed with the help of communication process diagrams.

RESULTS

The following communication process diagrams represent two examples of communication patterns found in chemistry classes (see Figure 3):

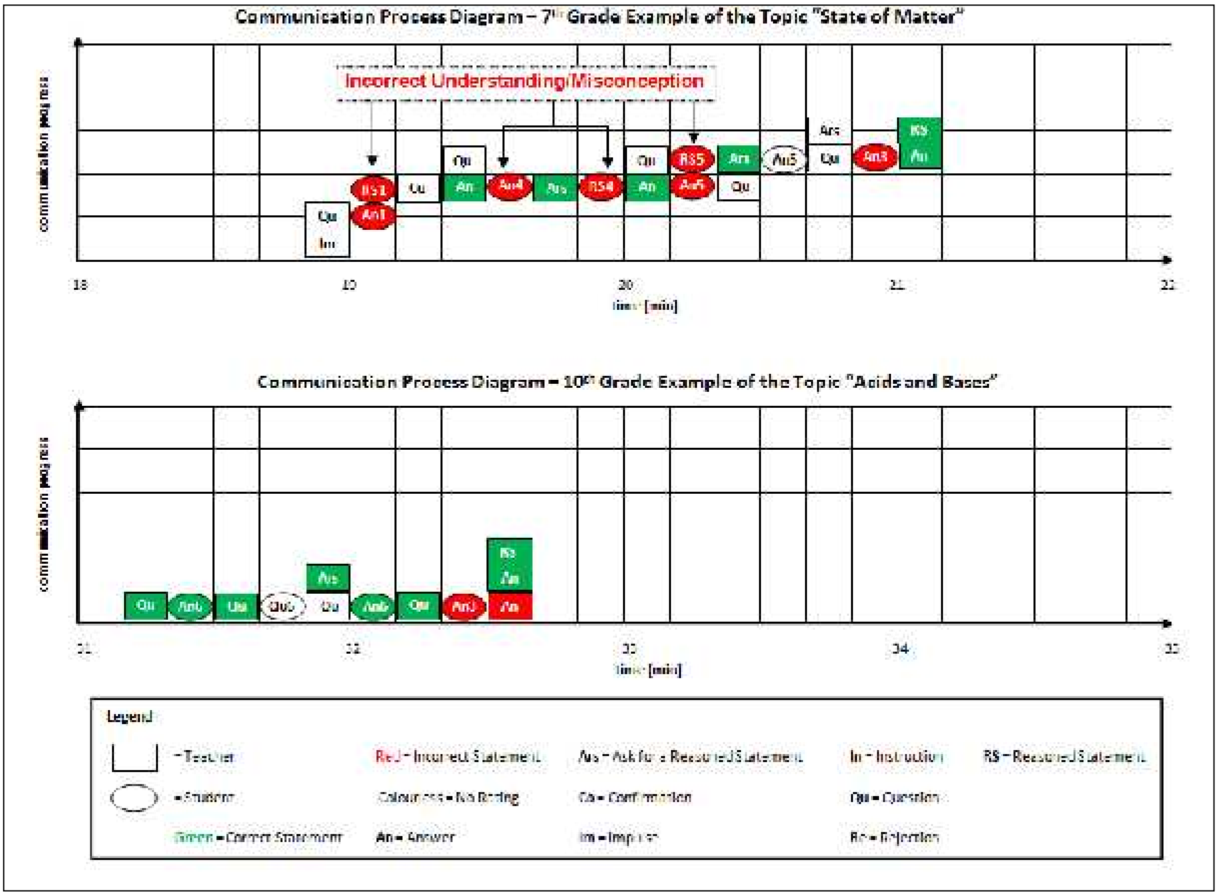

Figure 3. Communication Process Diagram/Example 7th Grade/10th Grade

In order to give a short example for one type of communication process (7th grade) we focus on the communication patterns from minute 18:50 to 20:20. The communication process starts with an impulse and a question of the teacher combined in one statement. Then student no. 1 gives an incorrect answer and a wrong justification. In this moment, the teacher might recognise and act on the incorrect reasoned statement to test if the student has an understanding which is incorrect from a scientific point of view (pointing at a misconception). Instead he continues the lesson with a confirming statement, the correct answer, and the next question. As student no. 4 gives a short incorrect answer, the teacher asks for explanation. The wrong justification follows and the teacher gives the correct answer and poses the next question. Then, a long statement with an answer and explanation, which are wrong from a scientific point of view, is given by student no. 5. This illustrates an incorrect understanding and indicates a new misconception.

The second communication process diagram shows a communication-sequence of two minutes in a 10th grade lesson on the topic "acids and bases". In minute 31:00 to 32:30, it is shown that the teacher dominates the communication by his way of narrow questioning. The teacher asks a short question which is correct from a scientific point of view. Student no. 6 gives a short correct answer, the question from the teacher follows and the next question from the student no. 6 is articulated. The teacher continues the lesson by giving an impulse and asking a question in one statement. As a consequence, the student gives the next short answer, the teacher poses the next question and the incorrect answer from the student no. 3 follows. There is no opportunity to identify students' misconceptions as the teacher does not ask them to justify their statements. A student-student or teacher-student discussion is important to learn about students' ideas. That is a fundamental prerequisite to understanding and dealing with students' misconceptions.

DISCUSSION AND CONCLUSION

The analysis of communication patterns predominantly shows that the course of the lesson is decisively determined by teachers' behaviour: Lessons are teacher-oriented and dominated by their activities. Verbal communication, even among students, is also controlled by the teacher. Primarily in 10th grade classes, teachers asked narrow, leading questions by putting the answer in their students' heads instead of leaving their questions open-ended. The teachers did not seem to take students' statements seriously. Providing instruction that takes students' misconceptions into account was barely possible, because extensive student-student and student-teacher discussions were not fostered. Reasoned student statements that would have highlighted any misconceptions were not supported.

In contrast, the teacher in the 7th grade example asked questions fostering students' reasoning and he seemed to be more competent in identifying students' misconceptions. One reason for this is that asking for explanation enhances the quality of learning and higher order questions challenge the learners to interpret, analyse, and manipulate information in ways that are not simply routine applications of previously acquired knowledge (Chi et al., 1994; Newmann, 1988).

The presented communication process diagrams can be a helpful observation tool for analysing classroom activities. One strong point of these diagrams is that they clearly illustrate the progression of the lesson and especially how teachers deal with their students' statements and misconceptions.

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