

PROFESSIONAL KNOWLEDGE OF CHEMISTRY TEACHERS

VIDEO ANALYSIS OF CHEMISTRY LESSONS

Holger Tröger¹, Martina Strübe², Elke Sumfleth² and Oliver Tepner¹

¹University of Regensburg, Germany

²University of Duisburg-Essen, Germany

Abstract: Research shows a distinct relation between the quality of instruction and students' achievement. Recent studies highlight the relevance of an appropriate use of technical language, the handling of students' conceptions, experiments and models for students' achievement and teaching. Nonetheless, research lacks scientific findings regarding the relationship between teachers' professional knowledge and their classroom action. Teachers' professional knowledge is subdivided into the three core categories content knowledge (CK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK). It can be investigated as an important aspect of instructional quality and seen as precondition for improving students' achievement and learning.

The presented study focuses on the relationship between secondary school teachers' professional knowledge, their acting in chemistry classes and their students' achievement and motivation. The analysis are conducted by high-inferent video analysis, students' achievement tests, motivation tests, and teachers' professional knowledge tests.

Currently, manuals for analysing videotaped lessons under aforementioned aspects of teachers' classroom action (use and dealing with technical language, experiments, scientific models, students' conceptions) are in the development stage, pre-tests are used and teachers' lessons are videotaped. This article presents the development of an approved content knowledge test and the first steps of the development of a PCK-test as well as the study's design and methodology.

Keywords: PCK, experiments, scientific models, chemistry language, students' conceptions

INTRODUCTION

Shulman (1987) proposed seven categories of professional teacher knowledge that are important for teaching. Today three categories pedagogical knowledge (PK), content knowledge (CK), and pedagogical content knowledge (PCK) are mainly discussed, especially in subject-specific education (Abell, 2007; Baumert et al., 2010).

Pedagogical knowledge is the knowledge about arranging a classroom atmosphere, which is supportive for learning (Krauss et al., 2008). Content knowledge on the one hand is the in-depth knowledge of the subject's content (Krauss et al., 2008) and its development. Pedagogical content knowledge on the other hand is the knowledge of arranging the content in an appropriate way for students and of teaching it comprehensible (Krauss, S., Neubrand, M., Blum, W., Baumert, J., Brunner, M., & Kunter, M., 2008).

This study investigates the relationship between teachers' professional knowledge and their acting in chemistry classes. Furthermore, the relationship between teachers' professional knowledge and their students' learning achievement and motivation is examined.

FOCUSING ON ASPECTS OF PCK

Teachers' professional knowledge is a complex conceptualisation including a lot of different aspects. This project focuses on four different aspects of PCK, teachers' handling of experiments, models, chemistry language, and students' conceptions.

Focus: Teachers' handling of experiments and models

Amongst others PCK involves the knowledge about models and modelling (Gilbert, 2004) and the use of experiments as one way of representing and acquiring the subjects' content and methods (Shulman, 1986). Studies (e.g. Maia & Justi, 2009) show that modelling activities support the learning process. Hence, PCK is assumed to correlate with teachers' handling of models and experiments, which supports learning processes.

Focus: Teachers' handling of chemistry language and students' conceptions

In addition to the aforementioned aspects, the use of technical language can be assigned to teachers' professional knowledge. Teachers' use and handling of chemistry language is an important precondition for developing students' language competency and domain-related understanding. Studies indicate the relevance of a high-quality use of technical language for students' learning achievement (Norris & Phillips, 2003; Wellington & Osborne, 2001; Yore & Treagust, 2006). Therefore, the handling of chemistry language can be assumed to be an indicator for PCK. Additionally, research points out the relevance of students' conceptions for the learning process (Scott, Asoko, & Leach, 2007). In consequence, the knowledge of students' conceptions and the dealing with them can be estimated to be linked to the teachers' PCK.

RESEARCH QUESTIONS AND HYPOTHESES

Figure 1 shows the examined relationship of teachers' acting and their PCK covering all four aforementioned aspects of PCK.

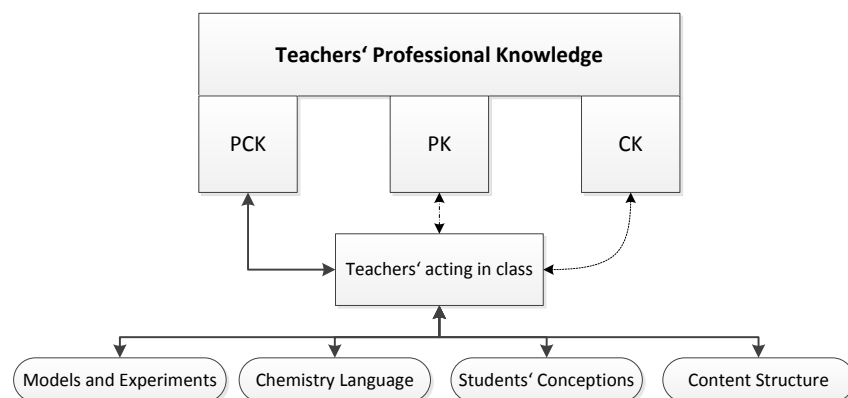


Figure 1. Investigation of teachers' professional knowledge by analysing their acting.

The assumptions lead to the following research questions and hypotheses:

- Q1: To what extent does teachers' professional knowledge influence their acting in class?
- H1.1: Teachers with a high professional knowledge show a more appropriate use of chemistry language and students' conceptions than teachers with a low professional knowledge.
- H1.2: Teachers with a high professional knowledge show a more appropriate handling of scientific models and experiments than teachers with low professional knowledge.
- Q2: To what extent does teachers' professional knowledge influence students' learning achievement and motivation?
- H2: Students show better learning achievement and motivation if they are taught by a teacher with high professional knowledge than if their teacher's professional knowledge is low.

METHODS AND DESIGN

In this study, video analyses are combined with paper-pencil-tests in order to collect data concerning the knowledge of teachers and students (Kagan, 1990). Using these two methods, the teaching of 40 chemistry teachers in 8 grade upper secondary schools will be analysed. The designated topic of the lessons will be the periodic table of elements and atomic structure. Figure 2 illustrates the test-design.

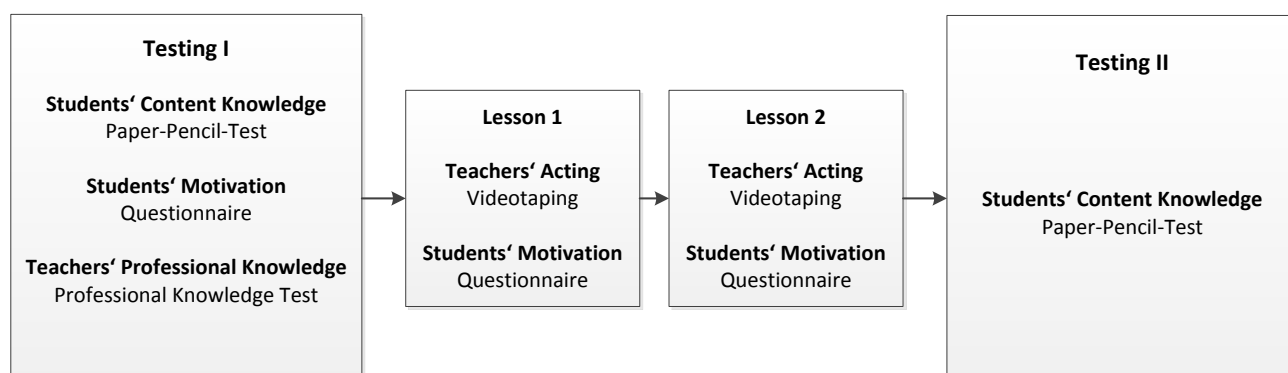


Figure 2. Test-Design.

Before the recorded lessons take place, teachers' professional knowledge will be surveyed using a developed and evaluated test from prior project (Dollny, 2011; Thillmann & Wirth, unpublished). In addition, students' motivation will be surveyed by a questionnaire and their previous content knowledge is gathered by a newly developed content knowledge test.

40 content knowledge test-items, constructed within prior and ongoing projects, have been evaluated in two different test-sets, each consisting of 25 items with an overlap of 5 items. The items were chosen and constructed to cover the taught content as broad as possible. The evaluation took place in spring and summer 2013 using Rasch Analysis ($N=149$). The test evaluation shows satisfactory item reliability (.92) and discrimination values ($>.54$). 30 out of 40 items have been chosen based upon their item functioning and used in order to create the final content knowledge test.

After the pre-test two consecutive lessons of the teachers' are videotaped. After each lesson, students' motivation is surveyed. At the end of the teaching to the aforementioned topic, students' content knowledge is surveyed by a post test. In addition to that, teachers' professional knowledge concerning the handling of chemistry language and handling of models is raised.

Teachers' Professional Knowledge Test

In order to survey teachers' professional knowledge regarding the aforementioned focus aspects a new test was constructed similar to the test of the prior project by Sabrina Dollny (2011). In this test, the study participant is presented a specific situation in which a fictitious teacher shows four different and independent opportunities for adequate classroom action. The study's participants are asked to rate each action on a rating scale from 1 (very appropriate) to 6 (very inappropriate). Using this test-pattern, each participant answers to 15 situations in which the teachers' handling of chemistry language is focused and 15 in which the focus is on the teachers' dealing with models. Referring to this pool of 30 items, two test-sets have been developed and evaluated.

The presented test was answered by 9 professors for chemistry education. Their combined expertise was used as reference for the test's scoring. This reference was used to evaluate the test, using answers of 49 secondary school teachers ($n_{test-set A}=26$, $n_{test-set B}=23$). The test shows a satisfactory to moderate reliability ($.51 < \alpha < .81$), depending on the observed scales and subscales.

The test items regarding the teachers' handling of chemistry language on the one hand and the handling of models were evaluated using different methods.

Handling of chemistry language

To evaluate the PCK-test regarding the handling of chemistry language, all answers on the 6 six-step rating-scale were recoded to fit a dichotomous scale, differentiating only between the participant's approval and refusal regarding the possibilities of action.

The aforementioned expertise of the nine professors for chemistry education was used to create a scoring key and all answers on the now two-step rating-scale were rated to be "right" (in line with the expertise) or "wrong" (not in line with the expertise). The evaluation of the experts' answers shows an acceptable reliability ($\alpha=.81$) and gives indications of the usability of items for the final PCK-test. These indications, item difficulties and discrimination, serve as a foundation for the item selection.

Handling of models

To evaluate the PCK-test regarding the handling of models, the expertise of the nine aforementioned professors for chemistry education is used to formulate relations between each four opportunities of actions per item. These relations rate each opportunity of action in relation to the other and form an ordinal order. The teachers' answers are evaluated based upon the relations and show an acceptable reliability. As a consequence, opportunities for action showing bad item discrimination were revised and three items of each scale were excluded from the final test. After revising the test, 12 items of each of the two scales were used for the current version of the test.

Video Analysis

The recorded lessons will be analysed in-depth under the mentioned focus aspects of teachers' professional knowledge using specific manuals for the respective video analysis. Each manual will be developed based on theory and video data from prior projects. In order to evaluate the constructed manuals for video analysis, each manual will be used by two raters to analyse five videos from prior video projects. As soon as the inter-rater reliability is acceptable (Cohen's $\kappa > .75$) the manuals will be used to analyse the projects video-data thoroughly.

The results of the analysis will be correlated to students' learning achievement and motivation and teachers' professional knowledge.

SUMMARY

Currently, the main study is in progress. The pre-tests are used to survey students' prior content knowledge to the topic of atomic structure and the periodic table of elements, and teachers' professional knowledge. The used test was constructed on basis of content knowledge questionnaires of prior projects and specifically developed items. Evaluation showed a good item reliability and satisfactory person reliability as well as decent discrimination values. After the pre-tests, teachers' lessons are being videotaped and the students' motivation during each lesson is measured. At the end of the teaching sequence, teachers' professional knowledge regarding the focused aspects of PCK is surveyed and students' learning gains content knowledge are measured. The teachers' handling of chemistry language and their handling of models is gathered using a newly developed PCK-test. A pilot study shows mediocre to satisfactory reliability values for the newly constructed test, depending on the measured scales.

The coding manuals for video analysis are in developmental stage. Till summer 2014, the forthcoming lessons will be videotaped and the in-depth analysis of teachers' classroom action shown in the videos will start.

Depending on the findings, the results will help to understand the influence of teachers' professional knowledge on teachers' actual acting in class and students' achievement and motivation. The findings will be of high value to improve the quality of teachers' education at university and school. In addition, the developed instruments should be an adequate alternative to analyse teachers' classroom acting faster and diagnose their professional knowledge more precisely compared to video vignettes.

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