INVESTIGATING STUDENTS' LEARNING, TEACHERS' DECISION MAKING, AND INSTRUCTIONAL PROCESSES IN PHYSICS TEACHING – VIDEO BASED RESEARCH FROM VARIOUS PERSPECTIVES

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Introduction to the Multiple Paper Set

In recent years research on science teaching has moved from investigating separate aspects such as students' conceptions or teachers' thinking to an investigation of the manifold interactions between students' characteristics, teachers' decision making, and specific features of instructional processes. The underlying idea of this approach is to identify indicators of successful teaching and learning processes by investigating the interplay of various factors that influence teaching and learning outcomes. This broader perspective became possible through the development of video techniques which allow analyzing in detail teaching and learning processes focussing on individual teachers and students as well as on whole classes and small groups.

As a completion of traditional tools of investigation video based research, therefore, has become a powerful tool to investigate teaching and learning environments in science education. Video studies have been employed to study the micro-structure of teaching and learning processes (Fischer, 1993; v. Aufschnaiter & Welzel, 2001; see also the bibliography by Pfundt & Duit, 2001) and to investigate the interplay of various variables of teaching and learning processes it school. There are studies on a national level (e.g., SALISH, 1997; Simmons et al., 1999) researching beliefs and classroom actions of teachers and international survey studies like the TIMS Video Study on mathematics instruction in the USA, Japan and Germany (Stigler et al., 1999) and more recently the TIMS-R Video Study on science instruction in Australia, Czech Republic, Japan, the Netherlands, Switzerland, and the USA (K. J. Roth et al., 2001).

Video studies provide rich data that allow the qualitative investigation of various aspects of teaching and learning processes. But coding procedures also provide significant quantitative data that allow correlating certain features of teaching and learning processes and teacher and student data of various kinds (like views, interests, and achievement) from interviews and questionnaires. In a process called "triangulation of methods" it is allowed to combine these data of qualitative and quantitative type (Bos & Koller, 2002, see also the "video survey methodology" of TIMSS-R Video; K. J. Roth et al., 2001). If actual classroom teaching and learning processes are documented the results are of particular significance for improving science instruction.

In the studies to be presented in the session video documents of actual physics instruction play the major role. However, teacher and student data are also available from various tests, interviews and questionnaires. The aim of the studies is to shed light on the processes of students' learning in the context of teachers' competencies, their decision making, and their actions in classrooms. In a classroom situation, teachers and students interact and constitute a structure of the interaction that can be analyzed from different perspectives. The first two studies presented in the multiple paper set describe the structure of physics lessons using various theoretical backgrounds. They illustrate how important it is to link the process of coding and analyzing a lesson to general and/or subject related pedagogical theories in order to achieve results that provide support for improving science education. The last two studies focus on the task of improving teachers' expertise and fostering their professional development at different stages of their career.

The studies are part of numerous German research projects that are using videos to investigate major deficiencies of science instruction and to provide a rich research base for improving instruction.

TEACHERS' INSTRUCTIONS AND STUDENTS' CONSTRUCTIONS IN PHYSICS EDUCATION: USING VIDEO TO INVESTIGATE HOW THEY MATCH

Obviously, science teaching and science learning are closely related. If teachers do not support und promote students' conceptual development, learning is hardly to occur. But if teachers demand too much from their students, again, learning might not take place. Therefore, for successful pedagogy the match between instruction and students' competencies plays an important role. For the study reported in this paper, previous research into students' development of physics knowledge was used to set up criteria in order to investigate demands of instruction and related students' abilities. Using video-data on instruction of two teachers into the concept of force, it was explored how dimensions of content, level of abstraction, and time could be used to describe the (mis-)match between teachers' instructional demands and students' situated understanding. Furthermore, the parameters were used to compare the different teachers' lessons and to relate teaching and learning processes to students' achievements.

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Theoretical Framework

The quality of teaching is, amongst other factors, influenced by the contribution of instruction to learners' development of new science understanding. If a student does not understand a given explanation or cannot use an experiment successfully in order to explore the nature of a particular physics law, the instruction fails. Therefore, processes of both instruction and learners' development of knowledge have to be investigated and related to each other. The project aims to explore process based methods to describe the quality of physics instruction in relation to students' constructions of physics knowledge. In order to describe students' constructions of physics knowledge, the following three parameters have shown to be useful for analysing educational processes (cf., C. v. Aufschnaiter & S. von Aufschnaiter, 2003):

(1) The contents to which a learner refers within his/her construction of meaning.

(2) The level of abstraction of students' constructions (cf., Piaget & Garcia, 1991). Four areas of abstraction have shown to be useful of which basically only the first two are developed by students of lower and upper secondary: (I) concrete (levels of *Aspects* and *Operations*), (II) abstract-stable (levels of *Properties* and *Events*) (for details on the levels and the results see C. von Aufschnaiter & S. von Aufschnaiter, 2003).

(3) The time learners need to develop meaning of a specific content and level of abstraction. Investigating the duration of students' cognitive processes we found that students do not spend longer than 30 seconds to develop a specific idea at a certain

level of abstraction and that they spend not longer than 5 minutes to grapple a task/problem (cf., C. von Aufschnaiter & S. von Aufschnaiter, 2003).

The three dimensions of content, abstraction, and time can not only be used to describe students' cognitive processes but also to investigate teachers' instructions. As both analyses refer to the same parameters, a relation of the results becomes possible. Such a relation can also contribute to a qualitative description of the "Zone of Proximal Development (ZPD)" (cf., Vygotsky, 1978).

Design and Procedure

Overview, Participants, and Data Sources

Data were gathered at the IPN at the University of Kiel within the project "Physics Video Study".[1] In total 13 teachers of grade 7 or 8 classes (students aged 13-14 years) participated. The first three lessons about the introduction into the concept of the electric circuit and the concept of force were videotaped. In addition, questionnaires on students' interests and situated experiences as well as measurements on students' achievements in the topics were provided at the beginning and the end of the school year. Further, in depths interviews were carried out with every teacher after the second series of lessons. For the analysis presented here two teachers were chosen for whom results on the questionnaires on students' interests and results of students' achievement largely differed. Whereas the class of teacher TS showed larger achievement gains over the school year than other classes but a somewhat disappointing development of students' interests in physics, it was the other way round with the class of teacher TB. Research presented here explores the first introductory lesson on force for both teachers in order to investigate whether content, complexity, and time can be used to describe the match between the instruction and students' knowledge. Furthermore, the analyses were used to generate hypotheses about successful content specific pedagogy in physics.

Methods

Video-data were transcribed in order to allow a detailed analysis of teachers' and students' cognitions. Referring to a second order perspective (cf., Marton & Booth, 1997) individual meaning was reconstructed from teachers' and students' utterances and activities. Often, especially teachers developed an idea within a succession of meanings which can be called "line of thought". Those lines of thoughts were used as the basic unit for further analyses: content and levels of abstraction were ascribed and time measured for teachers and students to develop a line of thought of a specific content at a certain level of abstraction. To demonstrate the procedure, Table 1 gives a short piece of transcript, relating line auf thought (referring to a specific content), its level of abstraction, and time needed to develop the succession of meanings.

Time	*Transcript*	*Line of thought*	*Abstraction*
20 sec	TB: O.k. Now we're talking about breakfast. Today, about one hour ago, some of you had breakfast to survive the day. You have to do it. Otherwise, something would be missing. What do you eat then, besides rolls and jam? Why do you it that?	Why do you have to eat rolls and jam for breakfast?	Operation

Table 1. Time, transcript, line of thoughts, and level of abstraction

Results

Content

In order to get an overview about the content specific structure of the lessons, content was investigated at different levels: First, lines of thoughts were analyzed. For instance, discussing which forces are familiar to students from their everyday experiences, TS and his students develop lines of thoughts referring to traction, atomic force, water force, and gravity (in total 0:55 minutes). Subsequently, sequences referring to the same area of content were identified. Finally, sequences were combined in terms of sections. For instance, TB's section on relevant forces included a sequence about collecting forces that play a role in physics and techniques, a sequence about magnetic forces, and a sequence about other forces (in total 2:00 minutes). Comparing the number of lines of thoughts referring to different contents as well as the numbers of sequences and sections developed (see Table 2) it can be concluded that TS spent more time on fewer aspects than TB did. From students' reactions during TB's lessons it became apparent that they were often not able to combine contents in the way TB was expecting from them.

Levels of Abstraction

Levels of abstraction ascribed to lines of thoughts show at first sight only slight differences between TS and TB. However, observing the processes in detail it is not only that TS avoids more often the abstract level of Events than TB does, but he also develops his instruction more systematically from concrete to abstract ideas. For instance, "jumping" back and forth in abstraction, TB takes in total 7:20 minutes to discuss with his students the difference between force and energy. In nine sequences he talks, amongst other things, about the similarities between force and energy, why we eat, what the body does with the energy while we sleep, and how we get rid of the energy. Within the three following sequences he asks students to argue about Obelix and whether he owns force or energy. Here, students were not able to give an immediate answer. From students' reactions it became apparent that they seemed to guess the answers rather than knowing about the differences.

Time

Time structures that were already reported for students' development of knowledge (see above) were also found amongst the teachers. They did not spent longer than 30 seconds for a line of thought and did not take longer for a sequence than 5 minutes (most of the time less than that). However, content and complexity of teachers' ideas developed within these time spans often differed from those of the students (more contents and/or higher levels). From the data it became apparent that already the time span of 30 seconds is crucial in terms of matching students' understanding.

To summarize the results, TS developed - in contrast to TB - less different aspects which he repeated more often. Moreover, he avoided the level of Events which is for students of that age difficult to understand (Table 2). Knowing about the dynamics of students' development of competencies it can be concluded that TS's instruction is more often than that of TB within the ZPD (cf., Vygotsky, 1978). This assumption also matches with outcomes of the measurements of students' achievements. However, it should be noted that all results only denote a certain tendency which has to be investigated in more detail.

	Teacher TS	*Teacher TB*
Total time of teaching activity (values rounded)	46:30 minutes	44:30 minutes
Number of teachers' lines of thought	98 lines of thought in 46:30 minutes	159 lines of thought in 44:30 minutes
Distribution of levels of abstraction of line of thoughts	Operations: 54 (55%) Properties: 39 (40%) Events: 5 (5%)	Operations: 79 (50%) Properties: 58 (36%) Events: 16 (10%) no attribution: 6 (4%)
Approximate number of different contents developed	16	27
Number of sequences developed	34	70
Mean duration of sequences (values rounded)	80 seconds	40 seconds
Number of sections developed	6	8
Mean duration of sections (values rounded)	7:50 minutes	5:30 minutes

Table 2. Comparison of content, complexity, and time developed by teachers TS and TB

Conclusions and Implications

Results demonstrate that the detailed investigation of processes of teaching, using the parameters content, level of abstraction, and time do not only allow to describe the quality of teaching but also its distance to students' situated competencies (measured with the same parameters). The method to investigate science teaching might be described as extensive. Therefore, it is probably not suitable to analyze routinely videos of teaching and learning processes. However, the method can contribute to the following areas of research and practice:

- general clarification of the mechanisms of teaching and learning,
- presentation and discussion of successful physics teaching within teacher education,
- individual coaching of teachers to help them to improve their own instruction.

Notes

The IPN Physics Video Study Team comprise: Manfred Prenzel, Inge-Marie Dalehefte, Reinders Duit, Manfred Euler, Manfred Lehrke, Lena Meyer, Christoph Müller, Rolf Rimmele, Tina Seidel, Maike Tesch, and Ari Widodo. [1]This project has been funded by the German Research Foundation within the Priority Program "BiQua" (www.ipn.uni-kiel.de)

SURFACE CHARACTERISTICS AND DEEP STRUCTURE OF GERMAN PHYSICS EDUCATION - RESULTS FROM A VIDEO STUDY

The study presented in this paper explores German physics education by means of teachers' questionnaires, video analysis and students' assessment in a longitudinal design over a period of one and a half year including four waves (panel design). The results strengthen the view that physics education fails the requirement of helping students to achieve scientific literacy. In addition, this study identifies some aspects of lesson design and teachers' conceptions that appear likely to have an effect on the average performance of German students. Where international large scale assessments are concerned, they may lead to poor learning results. The video analysis shows ways in which a new physics teacher education could enlarge teachers' repertoires of concepts of teaching and learning, and improve their ability to take students' learning processes into account during instruction. Unfortunately there is little evidence about which aspects of the educational theory that is currently applied really work in practice and what elements of it guide students to satisfactory learning outcomes. This is especially the case, since recently published results of the large scale assessments TIMS and the PISA study show disappointing results when they examine traditional aims and standards of education using empirical methods of investigation.

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Background, Aims and Framework

The approach adopted in the present study aims to find out "how things are working" in physics education. It involves first describing the status quo and then attempting to shape a theoretical background for improving strategies of teaching and teacher education. The study seeks to investigate everyday physics education in Germany, describing it on different structural levels to reduce the complexity of instruction and to explore correlations between different aspects of instruction and students' performance and attitudes. We may suggest that different lesson treatments cause different outcomes by guiding the students to different learning processes and cognitive skills. Obviously, a lack for variety of lesson treatments does not represent the whole scope of teaching and leaves the pupils with a narrow set of skills. It appears that similar problems also hold for physics instruction. As a consequence we assume that also physics instruction should draw on a variety of teaching and learning activities and should not restrict to some sort of "mono-culture". It seems that physics instruction might become more flexible if teachers start thinking about instruction at the students' learning processes instead of the content of the subject.

Oser & Baeriswyl (2001) developed a theory, which may be viewed as a "manual for teaching more efficiently". In order to simplify the idea of specific intended learning processes, they identify a small number of specific learning processes and related teaching aims relevant for classroom learning. Modifying their theory for physics lessons, we propose ten different types of educational aims. These are learning by experience, conceptual change, problem-solving, theoretical knowledge, contemplation, training routines, transformation of affective excitement, social learning, constructing values and personality and analyzing outlines.

This theoretical framework is employed to investigate teachers' concepts of instruction. In order to analyze the lessons we differentiate the following four levels: (1) The level of conceptual structure represents any kind of teachers' general knowledge relevant for instruction; (2) The level of operation sequences addresses the transfer of pedagogical knowledge into interaction; (3) The level of apparent structure summarizes all activities of students and the teacher in a specific lesson; (4) The level of students' learning processes covers the cognitive processes and their results concerning performance and skills.

Methods and Samples

We observe and analyze six teachers' concepts of instruction and their actual instruction. Each of them teaches one class. There are two different schools (Gymnasium in the city of Dortmund) involved. One of the schools is regarded as the interventional group. Four teachers of this school are trained once a week to plan and to perform their instruction using the above approach of concept types by Oser and Baeriswyl (2001). Two teachers of the other school form the control group. They do not receive the treatment of the interventional group. Video documents are taken from instruction on the following three physics topics: electricity, optics and Newtonian mechanics (force concept). The first topic, electricity, was taught in fall 2000 (grade 8), the last topic in early 2002 (grade 9).

The data base for investigating the teachers' concepts of teaching and learning, their ideas of physics education, and their estimation of their own role as teachers provide qualitative analyses of interviews and questionnaires. Analysis of the video-recordings of the lessons is guided by a coding system that was developed on the basis of the system used in TIMSS Video (Stigler & Fernandez, 1995). TIMSS categories for analysis were modified to describe interaction and learning activity in classrooms. The coding scheme had also to be extended in order to address specific features of physics instruction (like the role of experiments).

Results

This categorization of the "surface structure" (low inferent analysis) can be seen as a „key indicator" for distinguishing two types of instruction; other categories back up this distinction so that two groups of teachers can be identified: the instruction is labeled as „student-oriented elaboration involving experimental tasks" and „teacher-centered instruction using demonstration experiments". This distinction is also fostered by the very similar analysis of Prenzel and Seidel (et al., 2002) of 13 German physics teachers as described above. Therefore, this is a valid and general description of physics education in German Gymnasiums.

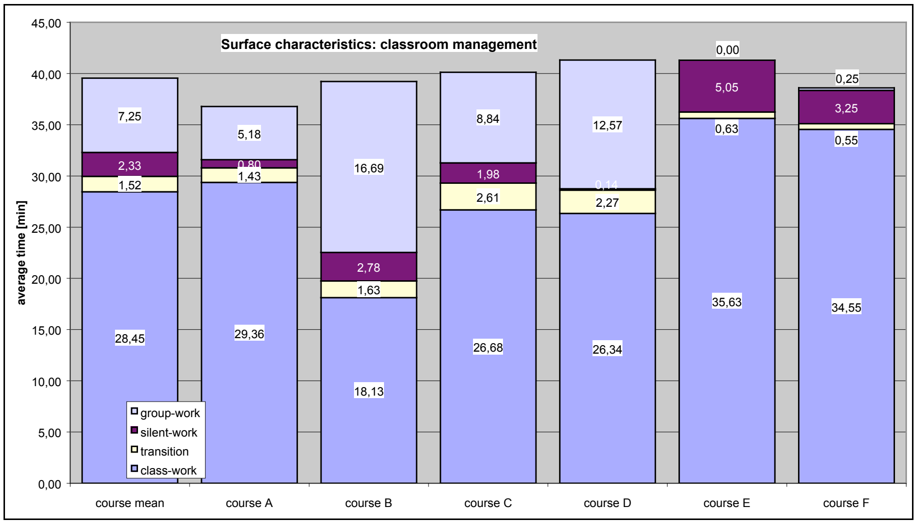

Figure 1. Main characteristics of classroom management

The analysis of the teachers' "deep structure" (high inferent analysis) indicates two types of education aims dominating the instruction: 'learning by experience' and 'constructing theory'. These types of aims that are much valued in the pedagogical discussions about science education, but other aims of similar importance rank at the bottom: 'problem-solving' and 'conceptual change'. Therefore this selection of types of education aims has to be estimated as specific for our sample but in terms of the theory of basic concepts the number of applied education aims is rather small.

The students' deep structure, so called "content operations" is not as narrow as the range of education aims shown above. But, it seems striking that very demanding operations rank very low, like: 'interpret/ compare/ verify', 'decide/ accept', 'generalize/ abstract/ integrate', 'delimit/ distinguish'. This may affect learning activities and cause typical deficiencies of students' learning outcome in Germany as seen in the PISA results.

Conclusions for Practice and further research work

To teach and to encourage teachers to change their teaching practice towards a balance of student-oriented methods is the first consequence of our results. Therefore teachers should change their concepts from planning lessons and teaching focusing primarily the subject matter to fostering the students' learning processes and to widen their repertoire of basic concepts of teaching and learning. Following Oser's theory a wider range of aims is supposed to bring about a wider range of (deep) structures during instruction, which should offer students the chance of a broader range of learning processes and cognitive skills and a better performance. The necessity of developing teachers' competencies towards taking into account the deep structure of their own and their students' action in the classroom is evident. Regarding the surface and the deep structure characteristics of the investigated lessons, the teachers already know more than one single solution of solving a problem of their teaching process. But, they do not apply many variations and their solutions are mostly incomplete. Therefore, training teachers to use a wider range of research based basic concepts seems a good way to increase the quality of teaching and learning in terms of students' performance (Fischer et al., 2002).

TEACHER STUDENTS ON THE WAY TO ANALYZE THEIR OWN PHYSICS TEACHING

In this study the development of reflection on own teaching practice into the pre-service teacher education in physics was implemented. Learning to teach physics is a long process which should early be guided by experts and appropriate tools. Over the past two decades, video has increasingly become a tool not only for documenting teaching and learning to teach but also as a tool for pre-service and in-service teacher students and practitioners to aid their reflection on practice. With the aim in mind to implement and evaluate a course in which pre-service physics teacher students can learn to analyze their own physics teaching, a seminar on teaching methods in physics was organized and evaluated regularly. Pre-service teacher students during this seminar get to know and practice a variety of different teaching methods. The results show that the students with this seminar get increasingly familiar with different perspectives on and criteria for "effective" teaching-learning-situations. In parallel to their own teaching they learn to reflect on their own teaching practice and factors which determine a teaching-learning situation.

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Subject

With this study I try to implement the development of reflection on own teaching practice into the pre-service teacher education in physics. Learning to teach science is a long and hard process which should early be guided by experts and appropriate tools. Over the past two decades, video has increasingly become a tool not only for documenting teaching and learning to teach but also as a tool for pre-service and in-service teacher students and practitioners to aid their reflection on practice. The potential benefits of this tool are, to a large extent, tied to the benefits of reflection on practice to the daily praxis of teaching. A critical advantage of this process is that teachers, students, and other stakeholders become aware of practices of which they are not conscious.

In addition, videos give us the chance to get an inside view of what happens in the classrooms and they are a precious tool to make us reflect upon it. We learn about how teachers teach and in some aspects also on how students learn. But mainly, videos are an important tool to let *teachers* know more about the learning and teaching processes in classroom. In that way, videos can be used to initiate a reflective process. This idea will be used in simulated teaching sequences to help science teacher students through their first teaching steps.

Usually, science teacher students experienced only a few different teaching methods in their own school life. But, from research in science education and general education we know that a variety of methods used in a course is important for the initiation of individual learning processes. Do the teacher students know and are they able to realize effectively different kinds of teaching methods, they will become able to support and assess individual learning in a classroom. To learn teaching methods requires action and practice within authentic teaching-learning situations, feedback and lots of time. These are complex demands with respect to the professional development of teachers. This professional development can be supported effectively through the use of videos and a guided development of skills for video analysis.

This view is based on the practice theory (Bourdieu, 1990) to understand both teaching and reflecting on teaching as different practices, and articulates the relation of the former (reflection on) to the latter (teaching). This relation, as W.-M. Roth et al. could show, is not a simple straightforward one (W.-M. Roth, Tobin, & Zimmermann, 2002). In particular, there are fundamental differences between praxis and reflection on practice that mediate (or limit) the benefits of reflection (W.-M. Roth, 2002). At best, reflection can serve to create plans for action with the hope that the type of situations reflected upon will repeat in future situations where the plans could serve as guides.

Design and Procedure

With the aim in mind to implement and evaluate a course in which physics teacher students can learn to analyze their own physics teaching, since three years I am organizing and evaluating regularly a seminar on teaching methods in physics where pre-service teacher students get to know and practice a variety of different teaching methods. The objectives of the seminar are the following:

1. For the teacher students to get to know different methodological approaches and tools to teach physics in different age groupsThe teacher students themselves shall simulate (practice) teaching methods and, experience these as teachers and as students (to get these both perspectives)
3. To implement video feedback as a method for reflection on teaching practice
4. For the teacher students to reflect on teacher‘s behavior
5. For the teacher students to observe students‘ behavior in detail with respect to the teaching method practiced
6. To realize links to science education theory and recent research results on teaching and learning science

The seminar is organized as a follow up of a weekly 45-minutes-simulation of teaching-learning situations (as they could be organized in real school practice) – each prepared by one or two of the participating students themselves. The other teacher students of the group represent the students in a classroom. A video camera stores the behavior of the learners (in this case of the peer students) and the actions of the teachers. After the simulation first an oral and then a video feedback organized in this peer group and guided by the scientist helps to reflect on the teacher students’ practice. The first part of this reflection starts with a small group discussion about the experiences made during the lesson. For the teacher students aspects of advantages and disadvantages of the teaching method and their realization become obvious. The students think and reflect on the activity, on the learning outcomes, on the difficulties and the personality of the teacher. These experiences are written down. After ten minutes, these experiences are presented in the whole group. Now, the discussion on equal and different kinds of view starts. Here, the view of the scientist can be put in and, the video gets interesting. Deeper looks into the teaching-learning-processes become necessary. The students start to discover new perspectives on the whole process.

The students from session to session work on their skills of reflection and, they learn to recognize individual and social processes which occur in the classroom when teaching physics through different methods.

At the end of the whole course, every student has to analyze his/her own videotape on the basis of individually defined teaching and learning aspects. These written analyses and the videotapes are the basis for this paper. In this study have been involved 44 Students and 36 different 45-minutes-simulations.

Data Analyses and Findings

In addition to the observations I made during the course, the written reflections of the students have been analyzed according to the individual teaching and learning aspects the students have focused on, and to the quality of the reflections.

The following example of a typical frontal teaching-learning situation, tried out within the seminar (winter term 2001/2002) shall illustrate the observations the student made.

The teacher student was organizing a classroom discussion. In his written analysis we can read the following (selected citations):

Classroom discussion – Report on the video analysis
Questioning
”The teacher himself formulated only questions and asked the students to think about solutions. These “not that constructive” questions activated some single students only. The rest of the class was outside of the discussion. Thus, we had a discussion of “specialists” only, and that we should avoid.”*Monologs*
“When we had long monologs of the teacher - and we had those - the concentration of the students decreased rapidly. We could observe activities of the students outside the teacher talk.”
Notes
“We forgot to collect students’ ideas at the blackboard which could have been written down by the students. With this deficiency we risked that the students forget the ideas until the next lesson.”

During all three courses, I could find a development of practice on analyzing videos on teaching situations and students’ learning processes: While at the beginning of the courses the teacher students have no ideas on what to focus on, they get increasingly familiar with different perspectives on and criteria for “effective” teaching-learning-situations. For example, they discover actions, reactions and behavior of the students in the classroom they did not observe or recognize during the teaching situation. They learn to see in which situations students work on the experiments or tasks, and in which not.

They learn to reflect on the interaction within these specific situations, and the language used. They discuss alternative practices.
For each of the practiced method it gets clear, what the specific conditions are to be realized, which teaching objectives can be followed, what interactive skills are necessary.

In parallel to their own teaching, the teacher students learn to reflect on their own teaching practice and on factors which determine a learning situation.

After the course, a good percentage of the students continue to use videos as a tool to improve their own teaching. Video therefore is used by the students increasingly in their individual teaching practice in parallel to and after the seminar

Contribution

With this study, two demands on pre-service teacher education have been put into the focus: The development of professional teaching skills, and the skill of getting to know and to use an appropriate tool for reflecting on own teaching. The results are important with respect to a further development of professionalization of teacher education

USING VIDEO DATA IN SUBJECT RELATED PEDAGOGICAL COACHING PROCESSES WITH PHYSICS TEACHERS

Many empirical studies show that teachers' professional competence is one of the main factors for the quality of teaching. Reports on traditional training courses for teachers in all phases of teacher education, aiming at long-lasting modifications of teachers' competencies, show only little effects even when these courses are prepared carefully and are oriented at everyday problems in classrooms (science education: Yerrick et al., 1997, general education: Boulton-Lewis et al., 2001). New approaches to an in-service teacher education program aiming at long-lasting modifications of conceptions and behaviours have to integrate ideas offered by research and practice fields in which enduring changes of behaviours depending on mental processes play a significant role. Theories of cognitive and emotive therapy promise to be an appropriate theoretical background of effective processes within teachers' professionalization. These theories focus on the transformation of an individual's problem specific frame of references and of his/her corresponding behaviour (Meichenbaum, 1977, Bandler & Grinder, 1992, Ellis, 1977, Dryden, 1995).

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Theoretical Background

In the framework of research on modification of teachers' conceptions about teaching and learning and of their decision making in classrooms videotaped teaching scenes play a significant role. For the teachers involved in this project, the significance results from the characteristics of their acting in classroom situations. Videotaped lessons of their own teaching give them the chance to become aware of the structure underlying their decisions and help them to raise this structure into a mental stage of awareness in which decisions and their justifications are accessible to reflections. In order to clarify these ideas it is necessary to explain the basis of the theoretical assumptions that have led to research questions and to the design of a research project using video data as an essential means.

Teachers' actions in classroom situations are characterised by the pressure of time in which a teacher has to react to a specific situation. According to Wahl (1991) a teacher's cognitive structures steering his/her actions are organised in such a way that a quick and reliable orientation in his/her professional field is possible. Rules of action are routines embedded in a set of comprehensive cognitive and emotive structures. This structure comprises a teacher's basic pedagogical content knowledge as well as his/her beliefs, judgements, emotions, and attitudes. Changes in a teacher's rules of action can only be successful and, above all, sustaining over a long time if they are accompanied by changes in his/her belief system that includes cognitive as well as emotive structures. Behavioural changes, therefore, have to be backed up by modifications in the system of personal beliefs. Otherwise any change in a teacher's classroom behaviour would fall back into former characteristics within a short period of time.

Prototypes of perceptions and prototypes of action plans including their connections are extraordinary stable and difficult to change. They are strongly influenced by a teacher's basic pedagogical content knowledge and his/her belief system. Modifications of a teacher's actions in classrooms are only possible when they are applied to the comprehensive cognitive and emotive structures which are more accessible to a teacher's reflective processes than the condensed prototypes of perceptions and action plans are. The figure below shows the structure of the different levels of awareness.

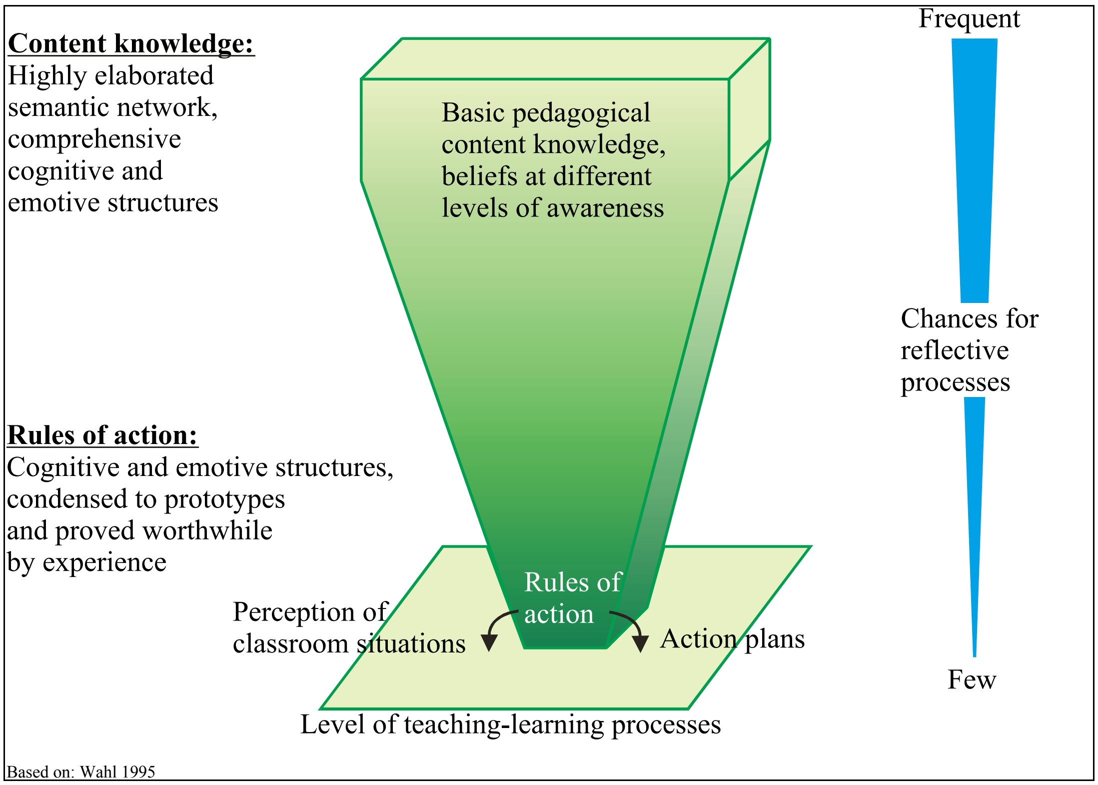

Figure 1. The long way from theories to actions.

In the project video graphed lessons play a significant role at different stages of the research processes. They help: the researchers to identify teachers' initial conceptions about teaching and learning; the teachers to become aware of problematic behavioral features in their classroom actions; and the researchers to find out the results of the coaching processes.

Research Questions

What are appropriate means to achieve the following goals:

- Teachers hold a cognitive-constructivist view on students' learning.
- Teachers' decision making in classrooms takes into account constructivist principles of teaching and learning.
- Teachers enlarge their repertoire of ways how to perceive a situation and of alternatives to react to situations.

Methods

It is obvious that a research project investigating the effects of coaching procedures in case studies has to start up with the identification of the involved teachers' belief system and of their rules of action. Therefore, the research design comprises the following phases:

- Initial analysis:
  - (A) Teachers' conceptions (beliefs and rules of action)
  - (B) Teachers' teaching practice
  - (C) Students' characteristics
- Treatments to change teachers' pedagogical and psychological expertise
- Final analysis (A), (B), (C)

In all phases videotaped lessons are an important tool with various functions.

<u>Initial analysis</u>

A teacher's conceptions about teaching and learning are identified by means of interviews. The interviews are transcribed in order to have a basis for identifying rules of actions in the interviewee's descriptions of his/her ideas about teaching and learning. For the purpose of a better communication with the teacher and of a concentration on the essential statements the teachers' ideas are transformed by researchers into a map structure which mirrors (1) his/her perception of classroom situations, (2) his/her ideas how to act, and (3) the expected results according to his/her goals which are underlying the actions.

The structures of a teacher's rules of action and his/her conceptions about teaching and learning have to undergo two different validation processes: In a communicative validation the teacher involved has to confirm or to modify the reconstruction of his/her conceptions. In a second step the relationship between the teacher's conceptions and his/her behavior in classrooms is investigated. The statements made by the teacher do not guarantee that his/her decision making in classrooms is congruent with his/her statements. Videotaped lessons enable the researchers to get to know which orientations are guiding a teacher's actions in classrooms and to contrast these orientations with their conceptions previously stated (validation in actions).

<u>Coaching process (treatment)</u>

According to the "Transtheoretical Approach" (Prochaska & DiClemente, 1984) a treatment structure describes six stages of a person's development from the stage without any intention to change to the stage of a stable modified behavior:

Stages of change - theory	Stages of change - teacher
Precontemplation	Teacher not intending to make changes
Contemplation	Teacher considering a change, weighting up pros and cons
Preparation	Teacher's decision to change a problematic behaviour development of goals and action plans
Action	Teacher is actively engaged in a new behaviour
Maintenance	Teacher is sustaining the change over time

Special interventions and methods by the coach help the teacher to master the transition from one stage to the next one:

Stages of change		Interventions
Precontemplation		
	_	Consciousness Raising
Contemplation		
	_	Self Reevaluation
Preparation		
	_	Commitment to Act
Action		
	_	Reinforcement Management
Maintenance		

Within the sequence of stages, "contemplation" has proven to be the most critical one because any decision of a teacher to change his/her owns behavior has to be preceded by the development of an awareness that it is worth to think about his/her present behavior. The essential role of video graphed lessons in the process of "consciousness raising" can be described quite clearly. These lessons lead teachers to think about the relationship between their intentions on the one hand and their actions in classrooms on the other.

Final analysis

The videotaped lessons enable the researchers after the treatment phase to find out whether or not teachers have changed not only their conceptions but also their behaviour in classrooms.

Findings

In several case studies it was possible to realize all phases described in the research design. Details of one of the case studies will be presented in the multiple paper set.

In general, it can be summarized that the processes of interviewing, structuring and validating are appropriate means to reconstruct teachers' rules of action and their conceptions. Research results indicate that in particular not experienced teachers show discrepancies between their statements and their decisions in classrooms. Therefore, the investigation of this relationship by means of videotaped lessons is an indispensable part of a coaching process.

"Consciousness raising" in the treatment phase very often happens without any intervention by researchers. The observation of details of his/her own behavior in relation to students' contributions makes a teacher aware of situations in which he/she decided in a way that is not consistent with his/her ideas about excellent decision making in classrooms

The problem how to enrich not only teachers' knowledge and their conceptions of teaching and learning but also their acting in classrooms could be solved by means of subject related pedagogical coaching processes which are oriented at theories of cognitive-emotive modification. These theories and their practical consequences have been adapted to the demands of an improvement of science education via the enhancement of teachers' teaching competencies. Research results show the importance of the process of "consciousness raising" which can be decisively supported by means of videographed lessons. Therefore, efforts to establish effective forms of teacher training aiming at in-depth behavioral changes should integrate this powerful tool.

Conclusions

The treatments proposed are appropriate means for working with very small groups of teachers. Future research should determine a program for more extensive procedures which include many teachers and therefore make possible a broader reform.

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