Physics and Didactics in Teacher Training for Secondary School

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Abstract

Young teachers, especially teachers educated for upper secondary school, find it difficult to organize and plan lessons according to the knowledge and ability of their pupils. Furthermore they know only little of educational research and have a limited awareness of different possibilities for presenting the subject matter.

To overcome these shortages we conduct a seminar on physics education with two objectives: The students should become acquainted with a whole variety of teaching methods applicable in physics lessons – kind of "tool kit". During a seminar there are presented more than ten different methods. The students decide which method and which physics content they want to present in a class like situation. During this lesson the "pupils" and their reactions to the presentation - interest, boredom, activity etc - are videographed and later analysed in the group on the basis of a theoretical reflection. This practical aspect is embedded in a theoretical foundation of a learning theory which focusses on activation of students (or pupils). So in this seminar we connect the aspects of practical activity, subject knowledge and results from research on learning processes. The experiences show that the students gain confidence in trying unusual methods. Furthermore they discuss possible learning difficulties that might be encountered by pupils at school. This was especially visible in a seminar jointly attended by student teachers for upper secondary school and lower secondary school. These students acted with quite different backgrounds which led to very fruitful discussions for all of them.

Introduction

In recent times following e.g. the work of Shulman (1986) many researchers have a focus on the presentation of content knowledge in teaching practice at school, partly from the view of content-related details (e.g. Viennot, 2001), partly from the view of implementation or the mise en scène (e.g. Tiberghien, 1997). This second perspective is strongly related to the methods applied in the physics lessons at school. Besides the presentation of physics concepts the intensity of learning - influenced by motivation, interest and activity - is decisive for the success of science education. Now: What *makes up* good teaching practice? Several aspects have to be considered: one aspect is the choice of topics of genuine interest to the pupils. The second is the appropriate choice of teaching method, which lies in the focus of this paper. Especially for the motivation of pupils in the long run the appropriate choice of teaching method becomes crucial.

Generally it can be said that approaches stressing the importance of the own activity of pupils seem to promise more success than others. According to studies on motivation and interest autonomy of the learners increases interest, hence their effort in learning. A learning environment that promotes the learner's own responsibility for his/her learning promotes intrinsic motivation and hence efficacy of learning. Hence it seems necessary to let the students gain experience with a whole bunch of teaching methods that fulfill these requirements and to show them how an activating implementation of a method may show more satisfying results.

However, during inital teacher training at university the theoretical and the practical parts mostly are taught separated from each other such that the students have great difficulties in connecting these parts. Moreover, they are mostly guided by strong beliefs in how teaching has to be organized. Their self-perception also may differ from the actual action in classes, (Fischler, 2001). These strongly held beliefs sometimes are an obstacle to the implementation of new results from didactical research. This might be one reason why few results of educational research find their way into the schools. The change of unappropriate beliefs of teachers is - as it is with students' conceptions - a very slow process, taking some time, especially if the teacher already has long experience at school. (Lang, 2001). So it seems appropriate to give the teacher students methods of how to organize, plan and analyse their lessons as early as possible.

Aim of research

Our primary goal is to contribute to the improvement of initial teacher training at university in the

above mentioned sense. Generally, we regard it important that the students learn to apply a great variety of methods for teaching physics contents as well as to plan lessons in the light of learning theories. Furthermore they should have the opportunity of reflecting their teaching practice in the sense of a metacognitive insight. The connection between these different aspects in science education should close the gap between theory and practice in teacher education.
The use of videoanalysis in research on learning processes shows them as a useful tool for viewing the details of learning and teacher-student interaction. We asked how this research tool could be implemented in teacher training in order to sustain the quality of training and increase significantly the learning effect for the teacher students with respect to their practical abilities.
So one of us (M.W.) developed a design of a seminar that explicitly connects practice in teaching with a theoretical foundation in learning theories and the subsequent video analysis of the students' own teaching in a unified manner.

Conduction of Seminar

In the seminar the students should have the opportunity of trying different teaching methods as early as possible and as often as possible. The participants already have sufficient physics content knowledge and should learn to convey it in an appropriate manner. The seminar should be kind of playground, where students may try their ideas, free of expectations or exams. Therefore they have the opportunity to try actions and methods in a fault tolerant environment; they can get support in their beliefs that they should teach pupil oriented, a view that else might not survive the first practical experiences (Fischler, 2001).
So during the seminar the students get to know a whole variety of methods, kind of "tool kit". They make practical experiences with often applied methods as well as with seldom used methods. Examples are: work at the blackboard, working with the textbook, taking written exams, role play, planning game, narratives in physics lesson, learning in stations, model making, "perform magic tricks", working with the internet, physics in the swimming pool (outdoor lessons), application of concept maps, toys in physics lessons, teacher-presented experiment, lab work, small projects etc. In a first step this yet not complete list of possible methods has to get to the awareness of the students. Their first reaction mostly is astonishment how many different methods they have at their disposition. Then each student chooses a method from the list to present it altogether with a physics content. Normally she has the time of about one lesson (45-60 Minutes) of presenting her method, while the other students mimic the class. Students also may use the opportunity of trying again a situation that occurred at school and which they want to analyse in more depth and/or in a new environment. Sometimes it occurs the other way round: students get encouraged to try a method at school they previously saw in the seminar. This encouragement is a very important aspect that should not be underestimated.
Besides the practical presentation the student has to explain the theoretical foundations and educational aspects of the method chosen. This close connection between practice and theory is regarded one of the key features of our seminar.
But the most important feature of the seminar is the video analysis: Each "lesson" presented in the seminar is videographed. The focus of the video lies on the behaviour of the students mimicking the class, the 'pupils': Has the method been implemented properly, were the participants being activated; did they have the opportunity of learning, in which situations did they seem interested or bored? The students should regard the video analysis as an opportunity to learn more about the effect of their practice. At the same time they become able to reflect their teaching on a scientific basis. It is essential that the analysis of video follows immediately after the "lesson"; kind of a stimulated recall discussion with aid of the video. The remembrance is fresh, but nevertheless the details are supported by reviewing the video. This immediate recall would in general not be possible with lessons at school. So in the seminar the students get immediate feedback and by the way learn methods to analyse their teaching. They can compare their goals, their intentions relying on their beliefs in the nature of teaching with the effect of their actions.
Besides this immediate analysis in the group each of the participants has to review his/her video on

his or her own and to deliver a written reflection of the lesson presented with a comparison between their intentions and the effects of the actual lesson. It is the goal that students learn to reflect their practice as soon as possible, to be able to judge the efficiency and the success of different methods.

Outcomes

The success of this design of seminar combined with exercises are evaluated in several ways:

- *formal method:* An evaluation sheet is given that the students fill in right at the end of the term
- *content related analysis:* Which aspects do the students find worthwile to mention in their written reflection?
- *informal feedback:* Utterances of students about the influence of the seminar during their school practice are gathered.

The *evaluation sheets* show that the students consider the seminar quite motivating and useful with a very good connection to practice at school.

Here we will concentrate on the *content related analysis,* showing up in the written feedback of each single student. It gives some insight into the manner how students get aware of the effect of their teaching. In some cases it shows that the analysis of video is very important for analysis of key moments during the lessons and hence provides deeper insight into the dynamics of a lesson and the process of understanding physics content. We have chosen some examples from the wirtten feedbacks of some students (here translated from german), describing the aspects of teaching the students could improve on:

Students derive hints for practical work and find alternatives to their first try:

> " The subsequent performance of experiment should have been combined with the work at the blackboard"

Through comparison with other methods presented they get ideas of how these methods could be combined in order to improve results with respect to motivation and learning of pupils.

Students search reasons for the reaction of pupils:

> " The pupils feeled bored which might have been promoted because of very little own activity of students."

During the presentation the students are quite occupied by their own activities. In viewing the video however, they can concentrate on analysis of the reaction of pupils. Now they have the possibility to recognize the reasons for the behaviour of pupils and to identify key moments of the lesson.

The students get aware of special difficulties in conveying physics content:

> "Every student could have explained the facts physically with scientific terms; but explaining it in a manner as simple as a child would do, turned out to be especially difficult."

They recognize the bandwidth of knowledge in different aspects - physics, cognitive psychology, and pedagogic - necessary to be prepared to possibly unexpected questions of pupils, to learning difficulties and the special needs of young children.

Students gain deeper insight into the role of teacher-pupil interaction:

> One student remarked, that the pupils had questions not directly related to his goals of the lesson, but were nevertheless important for the proper understanding. The answers to these questions seemed to enhance motivation and interest. He writes: "As I *only understand in retrospect* they [the questions] were an essential part of the dynamics of being motivated... Hence this part (of the lesson) was far more important than I thought before"

In this example the importance of the videoanalysis becomes visible: The students have time to analyse the teaching situation and the development of the pupils' behaviour. This may change their views of what is important for learning. In this way they can hopefully develop more easily the experience they need in order to notice the dynamics during a lesson. They recognize what influences the learning process besides the presentation of physics content or the implementation of the chosen method.

All these remarks show that the seminar seems to reach its most essential aims. At first the students see how many different possibilities they have to design their teaching. The video analysis shows them which features of a method contributes to activating pupils and which promote their learning. They recognize the mechanisms occurring in a lesson and identify key situations. They find out the advantages or disadvantages of certain methods and learn several alternatives of implementing them. Besides they experience how important it is to have a solid knowledge of the physics content in order to be able to react flexible to the utterances of pupils and to recognize preconcepts and learning difficulties.

A few words about the *informal feedback*: We usually get informal feedback from our students with remarks that give some hints to the long-term-effect of the seminar and are quite encouraging. Some students try the experienced methods at school, some find a subject for their thesis. The seminar seems to have an inspiring effect on the activity of students.

Conclusion for initial teacher training

Normally teacher students for lower secondary school (later teaching grade 5 to 10) and for upper secondary school (later teaching grade 5 to 13 at Gymnasium) attend different courses. Especially students for upper secondary school concentrate on the physics aspect and only a very limited part of their study is provided for educational aspects. Hence, the amount of methodological knowledge of these latter students is quite reduced. Hence it is necessary hat they acquire more knowledge on a scientific basis, before they enter the practical phase of their training. We have seen in the first seminars of the kind described that a great variety of different methods in physics teaching in combination with video feedback of the practice parts show impact on the views and beliefs students develop about teaching at school. How suitable and good a single method might be - in teaching at school a great variety of methods prevents the monotony.

Generally it can be said for all students, that they should be more sensibilized for the importance of key moments in a lesson. A suitable tool seems the videotaping of lessons and the subsequent analysis. If the students recognize key situations in a video of their own lessons they review more easily their own behaviour. Furthermore, the use of video dates opens the students the possibilitiy of analyzing their teaching on their own or - if they wish - with the assistance of a supervisor.

The seminar is now being conducted in a way that students both for lower and upper secondary school attend the seminar together. This leads to very fruitful discussions because the views on pupils, their needs and their learning differ significantly between these two "cultures". They complement each other with respect of educational aspects and physics content related aspects and the students show great interest in each others views and experiences. This interplay we will analyse in more detail in future seminars in order to reach recommendations for teacher education for lower as well as for upper secondary school.

Further research project

All measures to improve the quality of education in physics by improving the action of teachers can show significant effects only in the long run. Some seminars with this design served us as a series of first pilot studies. So the presented study can be seen as a first step towards an efficient teacher education. All the experiences gathered influence our further research project. The next step is to follow the students in their further professional development and reveal the effects of the seminar design in order to get results which show how it can be improved. So a longitudinal study will

follow for evaluating the long term success. When the students enter the second phase their development should be reviewed in a first step.

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