Working with tasks for the learning of problem solving in maths teaching as an issue of the first teacher training phase

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Abstract: This article describes learning goals of teacher training for the working with tasks in maths lessons. Selected common and different features of tasks intended for the learning and performing are especially referred to.

Kurzreferat: Das Arbeiten mit Aufgaben stellt für Mathematiklehrerinnen und -lehrer einen Kernbereich ihres professionellen Handelns dar. In diesem Beitrag werden Lernziele für die universitäre Lehrerausbildung formuliert, die die Studierenden für dieses Arbeiten mit Aufgaben befähigen sollen. Dabei werden ausgewählte gemeinsame und unterscheidende Merkmale von Aufgaben zum Lernen und Aufgaben zum Leisten besonders berücksichtigt. Die Ausführungen werden anhand eines durchgeführten Projektseminars „Problemlösen lernen“ konkretisiert.

ZDM-Classification: B50, C30, D50

0. Introduction

While teacher training is encountering increasing interest at the German universities the required modularisation of the study programmes has to come up to the expectations of an improved professional competence. If tasks – in a larger sense understood as an incitation to active learning– play a central role in the planning and structuring of math teaching in all school types the necessary basis for reflected “working with tasks“ (which would include the construction, choice and kind of application in the teaching and learning process) has to be established already in the first education phase. Therefore a step-by-step-concept was developed with obligatory basic requirements for all students and optional possibilities for intensification that are, among others, treated in a project seminary about the learning of problem solving. This teaching seminary was evaluated and differentiated in the frame of a DFG supported project in 2003.

1. Teaching targets for the working with tasks in maths lessons

A subdivision in three concretised target categories, as used by Weinert in 1999, may serve to describe the competences for the “working with tasks“ to be developed during education and further training of teachers, also on the basis of the reflections made in the article by Büchter and Leuders in this volume.

Target categories	*Concretisation or competences for the “Working with Tasks”*
Intelligent knowledge for the working with tasks in maths lessons	– wide task concept (task as incitation for active learning) – knowledge of different types of tasks – knowledge of criteria to analyse the learning potential of a task and methods to use it – knowledge of possible task variations – concepts for the interlinking of tasks (creating learning environments)
Acting competences	– problem solving competence – competence regarding the potential and functional analysis of tasks – competence in the variation and construction of tasks for the learning and performing – competence in developing task-based learning environments – diagnostic competence to analyse student solutions
metacognitive skills	– competence of reflecting on how to exploit the potential of tasks in teaching/learning situations

Tab. 1: Target categories for the “working with tasks”

All these mentioned and of course desirable, however very demanding targets can only be reached in the long run and as a result of first training phase, traineeship at school and further teacher training.

In the frame of an obligatory seminar for the introduction to teaching methodology at the TU Darmstadt the students get acquainted with one general task concept (tasks prompting action) and different kinds of tasks – e.g. with respect to the target of action (cf. Bruder 2000), the degree of difficulty, the potential of activation, the formats like multiple choice and according to their didactic function – from safeguarding of the starting level through elaborating of material and homework to systematising and testing.

The consideration of different viewpoints on the analysis of tasks is followed by a synthesis of different analytic aspects. For example, the integration of certain types of tasks in typical recurring didactic situations is discussed with the students. Such a didactic situation might be the saving of basic knowledge and of necessary elements of the starting level before proceeding to new learning contents.

Basic knowledge can especially be saved with tasks containing elements which were already understood – e.g. by means of a “learning journal“ (Bruder 2001). The following question formats proved suitable:

- The starting example to introduce the teaching unit shall be described in own words: What was the subject?
- A basic task on a new fundamental concept, method or connection together with a possible inversion is given and shall be solved.
- An example shall be given where the new method or the new connection can be applied – and where not!

> "Give one term which can be simplified by using the 3rd binomial formula and one where this is not possible."
>
> "Give one connection which can be described with the mathematical form a•b=c and one where this is not possible."

Fig. 1: Examples

– What typical mistakes can occur when dealing with the new concept, method or connection?

These questions are suitable to start a teaching unit and for self-guided processing by the students. It is recommended to ask the students to keep a learning journal on the new subject, beginning just after the first lessons, before complex exercises and applications are started. This learning journal should not be assessed but carefully evaluated as it constitutes a bridge between learning and performing. The students are clearly informed what is expected of them and where they rank – long before a final test. The method of a "learning journal" also helps the students find sense making learning goals and assume more responsibility for their own learning.

The variation or modification and opening of given tasks is another training aspect. With these exercises the students obtain the ability to understand the learning potential of a given task and to intentionally use it for determined learning processes or to try out special competences.

Such exercises, meant to improve the teaching culture, also play a central role in further training courses for teachers.

2. Consolidation and application of the principles for the working with tasks in a project seminar on the learning of problem solving

In the frame of a project of the DFG programme "quality of school education" at the TU Darmstadt an optional seminar on the learning of problem solving in maths teaching was developed, run and evaluated in the summer semester 2003 (cf. also Komorek/Bruder/Schmitz 2004). This seminar also covered the central competences for the learning of problem solving that have to be gained by teachers for the working with tasks. The seminar was structured as follows:

1) What should be understood as learning of problem solving in maths lessons?
2) Which concepts for the learning of problem solving do exist with which in-class consequences and evaluated results?
3) Which new / explicit learning contents are important?
4) How can the learning of problem solving be made possible for all students in maths lessons? (conception of task-based learning environments)
5) What is a good problem solving task with respect to learning and performing?

Learning of problem solving can be defined as getting acquainted with and making use of methods for the solution of tasks with individual degrees of difficulty. Though it is not possible to go into the different background theories on the learning of problem solving, one pragmatic extract will be presented to demonstrate the positive influence on the in-class learning success by embedding (potential) problems:

Following the procedure shown by their teachers the students learn to ask themselves the three following questions and to put the answers down (e.g. in a learning journal) before they tackle a difficult task:

– What is the problem about?
– What do I already know in connection with the problem?
– What methods and techniques can I use?

After a first attempt to solve the problem – at first alone if possible, then in exchange with the learning partner and finally in comparison with a group or in class – when results and (different) possibilities of solution are presented, the (individual) learning benefit of this task has to be worked out explicitly:

– What kind of maths helped us solve the problem?
– What strategies were useful?
– What was new to me? Which questions remained open?

This intends to underline that the learning potential included in a task is not automatically exhausted in class and requires a methodological explication. The absolving of tasks schemes or standardised tests alone will not suffice to help the students reach a potentially possible knowledge increase. In contrast with a test situation, causes for reflection can be created in class with additional questions on meta level, allowing a knowledge increase.

Open tasks, especially multistep tasks whith a closed elementary partial task generating further partial tasks with open end are, due to their self differentiation, most suitable for exercises. They can also serve for standardised tests, if the openness of their results is reduced. Questions with open results and creative and communicative elements which will probably not occur in tests are nevertheless an important element that can teach students to flexibly move within a subject allowing them to act more freely in test situations.

However, specific closed tasks, used for example as model tasks for the learning of an heuristic strategy, can also be of excellent value to the learning and may also become suitable for the performing after some small modifications of the context:

> "A man picks up apples. On his way back into town he has to pass seven gates. There is a guardian at each gate who claims half of his apples and one apple extra. In the end the man has just one apple left. How many apples did he have first?"

Fig. 2: "The seven gates task"

This problem especially demonstrates the heuristic strategy of "working backwards". Examples of further heurisms can be looked up in the task data base http://www.madaba.de/.

The students often use those model tasks as a mne-

monic for similar situations. But this is not yet enough. Elements should be added to the learning environment of problem solving that are not necessarily taken up in a test, e.g. the request to imagine everyday situations which also require backwards thinking and acting (looking for a key or glasses, finding the way back home from a specific place). Such tasks are of central significance for the students to better understand the sense and correlation between the things they have to do with in their lives and those that have to be learned in maths lessons.

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