MODELING IN THE CLASSROOM – MOTIVES AND OBSTACLES FROM THE TEACHER'S PERSPECTIVE

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Modelling is not only written into educational standards throughout Germany; other European countries also stipulate the integration of reality-based, problem-solving tasks into mathematics at school. In reality, however, things look quite different: in many places maths lessons are still dominated by exercises in simple calculation. So why? What is stopping teachers from introducing modelling? What would motivate them? In order to explore this issue in depth, a supplementary empirical study was conducted as part of the EU Project LEMA[1]. This paper intends to introduce the project, the development of the questionnaire and the survey design. Finally, first results will be presented.

THE LEMA PROJECT TEACHER TRAINING PROGRAMME

Within the framework of LEMA (Learning and Education in and through Modelling and Applications), a concept for a further training course for teachers on the theme of modelling and reality-based teaching was developed, piloted and evaluated. The aim was for teachers to become familiar with contemporary didactic and methodical concepts. They should acquire a basic knowledge of mathematical modelling and reality-based tasks in the school context, and after the training, they should be aware of why modelling should be learnt in maths lessons and how their pupils can learn it. In other words, they should know which subject matter, teaching forms and methods are most suitable for supporting pupils in their learning, at which point in the lesson modelling can be introduced and how a basic knowledge can be secured. In addition, practical concepts for putting together and evaluating and grading tasks for class tests should be acquired. A further aim was to be able to analyse, modify and describe the learning potential inherent in modelling tasks, and to be able to develop tasks which take into consideration the heterogeneity of school classes[2].

The course content was designed for about five days of further training. The modular structure of the course allows for a choice of content and is flexible in terms of the length of the training. Furthermore, it is conceived in such a way that teachers from all types of schools and of all academic abilities can take part. In Germany, two parallel training courses were to take place on five days spread out over the year (Jan. 08 – Nov. 08). There should be about two months

[1] LEMA = **L**earning and **E**ducation in and through **M**odelling and **A**pplications. Coordinator: Katja Maaß Pädagogische Hochschule Freiburg. Participant countries: DE, EN, FR, ES, HU, CY

[2] www.lema-project.org

between each day of training so that the teachers participating in the course have the opportunity to integrate the contents of the training into their lessons.

BASIC THEORY

Mathematical modelling generally refers to using mathematics to solve realistic and open problems. At the same time, the exact definition varies depending on the aims, which model of the modelling process is being used and the nature of the context assigned to a modelling task (Kaiser-Messmer 1986, Kaiser & Shiraman 2006).

Obstacles to the integration of modelling

In day-to-day school life, modelling still plays a much smaller role than one would wish (Burkhard 2006, Maaß 2004). It appears that at the moment teachers see more obstacles to using modelling than advantages. Blum (1996) has divided these obstacles into four categories: organisational, pupil-related, teacher-related and material-related.

Organisational obstacles: With this Blum (1996) is referring mainly to the short amount of time – 45-minutes – teachers have for class.

Pupil-related obstacles: Modelling makes the lesson too difficult and less predictable for pupils (Blum/Niss 1991, Blum 1996). Pupils can have difficulties carrying out individual steps or even the whole modelling process (Maaß 2004). Standard calculating tasks are more popular with some pupils because they are easier to understand and to solve the problem one simply has to apply a certain formula. This makes it easier for pupils to get good grades in mathematics (Blum/Niss 1991).

Teacher-related obstacles: There appears to be a variety of obstacles for the teachers. The literature on this issue refers repeatedly to the time aspect. Teachers need more time to update tasks, to adapt them to the needs of the respective class, and to prepare them in detail (Blum/Niss 1991). In addition, there are obstacles in relation to the actual lessons: teaching becomes more demanding and more difficult to predict (Blum 1996). Furthermore, a teacher requires other skills and competencies in order to be able to deal with a changed approach to teaching. The latest literature also refers to teachers' beliefs about – or attitudes to – mathematics teaching as being an obstacle to innovation in the classroom (Pehkonen 1999, Törner 2002). Blum (1996) emphasises the fact that teachers do not view modelling as mathematics. Moreover, some teachers do not consider themselves competent enough to carry out modelling tasks when the context is taken from a subject area they did not study (Blum/Niss 1991, Blum 1996). In addition, a significant aspect of the perceived obstacles is the question of how to assess performance, as teachers feel overwhelmed by the increasing complexity of this process (Blum 1996).

Material-related obstacles: Teachers often simply do not know enough modelling examples which they feel would be suitable for their lessons, or they select excessively detailed materials. (Blum/Niss 1991, Blum 1996).

Motivations for integrating modelling

Though there are several arguments against modelling, one can counter these arguments with numerous good reasons why modelling should be integrated into mathematics lessons, despite the existence of the obstacles as described above. A comprehensive representation of these reasons can be found in Blum (1996, p.21 ff.), Galbraith (1995, p.22) and Kaiser (1995 p.69).

The offer-and-use model Figure 1 shows an attempt to integrate influences on the quality of teaching into a more comprehensive model of the effectiveness of a lesson.

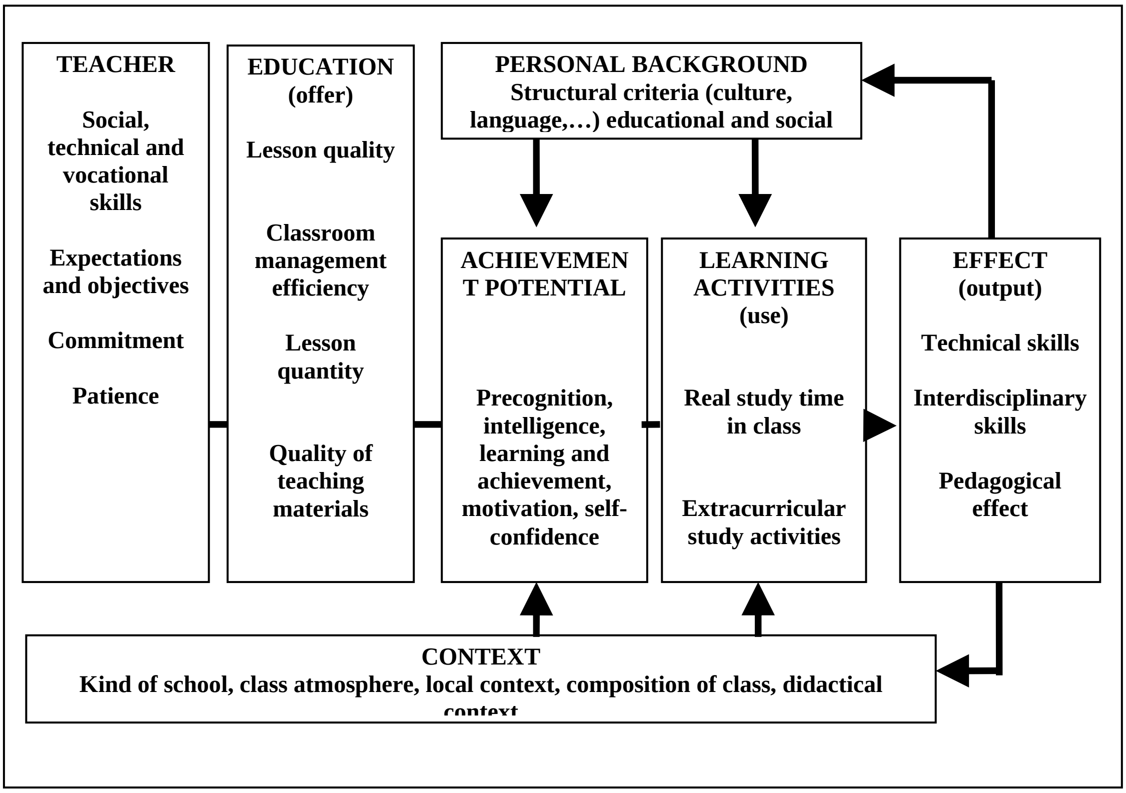

Figure 1: Offer-and-use model; Source: Helmke (2006)

As well as characteristics of the lesson, the model also includes characteristics of the teacher's personality, the classroom context, the individual personal background requirements and the achievement potential and learning activities of the pupils. This model represents a theoretical basis for the obstacles and motives for modelling. At the same time, the model should serve as a basis for systematically organising the reasons for motives and obstacles so as to indicate in which areas of the model the relevant motives and obstacles are to be found. For example, the interviews produced a first indication that the motives belong to the pupil domain and the obstacles with the teachers.

RESEARCH QUESTIONS

The previous section set out some arguments against modelling. However, these are based almost exclusively on experience and have not been subjected to empirical analysis.

This suggests the need of some kind of instrument with which to measure or assess empirically the arguments against modelling. In order to ensure the resulting point of view is not one-sided, this instrument should also analyse the arguments *for* modelling. This has the additional advantage that not only the deficiencies are revealed, but that solutions are also presented and made available. Therefore, the central questions for the survey are:

(1) What are the obstacles and motives? (2) Which obstacles and motives appear meaningful in terms of their being put into practice? (3) Which changes in the obstacles and motives can be identified during training? (4) Can in the process certain types of teachers be identified? (5) Is there a rubric for the offer-and-use model which seems to be especially relevant?

How these questions might be answered is presented in the following.

METHODOLOGY

Survey for the study: To find out which aspects teachers view as obstacles and motives for modelling, quantitative and qualitative methods were applied. Amongst other things, a questionnaire was designed with the aim of ascertaining the obstacles and motives (see next section).

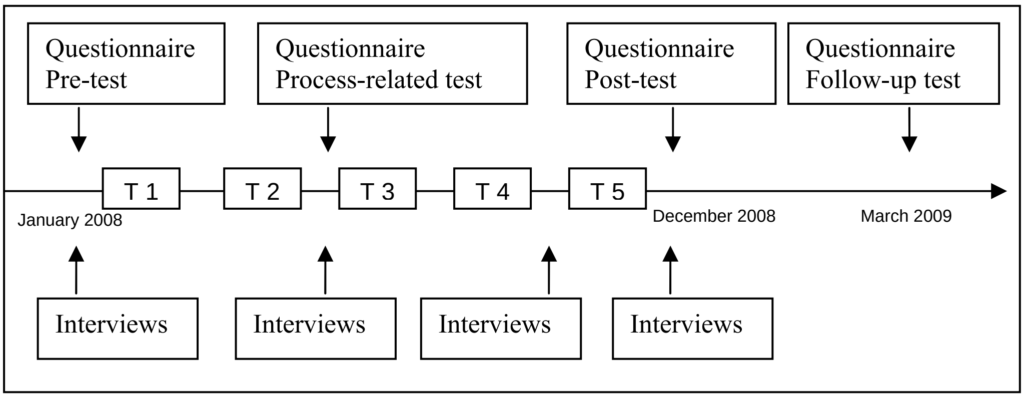

Figure 2: Study schedule

In addition, guided interviews were to be conducted. The advantage of using questionnaires is that a very large number of subjects can be used and that the questionnaire can be highly standardised (Oswald 1997). Only then can the desired generalisation of data be achieved. Significance tests can be applied to test hypotheses and develop a general statement (Bortz & Döring 2006). However, questionnaires are also limited in that data acquisition is not based on a process but mainly only focus on specific points. A further disadvantage lies in the reduction of the information: due to the pre-defined answer format of the questionnaire, the possibilities available to the survey subjects when providing their comments are limited.

Therefore, ideal is the additional use of interviews (Flick 1995). This allows the subjects the opportunity to express their answers in a more open form (v. Eye 1994). Using a set of interview guidelines, the interviewees are granted as much space to provide their own descriptions as possible. Where something is not clear, this type of interview affords the researcher the chance to ask again, to rephrase the question of to explore in more depth spontaneously and associatively things the interviewee might say (Hopf 1995). A central element to research questions is also that in addition to ascertaining obstacles and motives, the interviewer can enquire as to the background behind the arguments.

Study design: The questionnaire was to be implemented at four points in time: pre-test, post-test and follow-up test, as well as a process-related test in the middle of the further training). Four different survey dates were chosen so as to be able later to discover a possible development curve or teacher types. At the same time, additional individual interviews should be conducted with six teachers chosen randomly. So far, the results of the pre-test and process-related test questionnaires are now available for this study. The first and second interviews of the selected subject group are also available. More data will be generated by the end of the year.

Random sample: The random sample includes teachers from two further training courses with a total of 52 participants and a corresponding control group of 47 subjects. The allocation to experimental or control group was random.

The random selection of the teachers for the interviews was based on the results of the pre-tests. This meant that three teachers were selected who saw many obstacles to modelling and three who instead saw many motives for modelling.

Finally, table 1 is intended to show which assessment tools were chosen, their basic structure, their usage during the study period and a brief description of the respective random sample.

QUESTIONNAIRE DEVELOPMENT

To lay the foundations for the study, a questionnaire was developed whose purpose it was to throw light on the obstacles and motives for the teacher regarding modelling in mathematics lessons.

To be able to guarantee this, a three-stage design was developed.

Questionnaire development: The first items were developed from the subjective theories of researchers (deductive item construction). For this, the *obstacles* described above were restated as items. Furthermore, items were also formulated from the identified *motives*. To guarantee the authenticity of the items, the "natural" polarity of the obstacles and motives were retained in the items. The result was a preliminary questionnaire which included a total of 65 items. The answer format corresponded to a 5-level Likert scale (Rost 1996), which ranged from "applies completely" to "does not apply at all". As the items named on the questionnaire were not expected to prove complete, additional open questions were integrated which allowed the subjects to add any obstacles and motives for modelling which were not mentioned. With the help of these open items, together with the evaluation and optimisation of the closed items, the aim was to create a second and third test version of the questionnaire. This was necessary in order to be able to change the phrasing of items with ceiling effects, thereby minimizing the effect. At the same time, it was important to check the changed items once again in another test version in order to ensure that all ceiling effects were eliminated. If for the third test version no changes can be made to an item, it is removed from the questionnaire. Another reason why the three test versions are necessary is that the open question format generates new items which also have to be checked in a test version for ceiling effects.

The questionnaire was tested on 240 mathematics teachers in three runs. In the end, the questionnaire included 120 items.

Item polarity: The effects of item polarity are a source of controversy in the literature (Bühner 2006, p. 66f). On the one hand, some people are of the opinion that negatively expressed items confuse (e.g. “I am not often sad”). On the other hand, the tendency to say yes should be counteracted. Questionnaires with positive and negative items influence both factors and validity. Other studies have proven, however, that item polarity has only a limited effect on studies (ibid. p.66f). Due to these contradictory points of view regarding item polarity, in this study the natural polarity of the items was retained. This means that a high level of validity for the questionnaire is assumed, as the items in their natural polarity are less ambiguous and clearer. Thus the questionnaire includes both positively and negatively formulated statements about the research topic.

Forming categories: The aim was to organise the 120 items into categories. At the same time, the categories should be formed from the items (inductive categorisation). The first indications for categories were provided by Blum’s classification (1996) as illustrated above. In addition, the items were repeatedly analysed together as a whole, so as to check for more possible category indicators. In so doing, a great deal of flexibility and openness was extremely important. Through this dynamic process new categories of content were constantly being discovered and others rejected. In addition, a categories validation was carried out by an expert rating, whose task it was to check if the categories were consistent in terms of content.

In the end, the items generated 23 categories. In conclusion, the categories were assigned the aspects of the offer-and-use model (fig.1) so as to give them a theoretical base (deductive approach). These are described in the following.

FIRST RESULTS

In developing the questionnaire, the areas in which teachers see obstacles and motives for modelling were indicated. As the data collection is still incomplete, a final evaluation can not yet be given. Instead, it is more important that the categories be seen as a first indicator of to which areas the various obstacles and motives can be assigned. Thus the intention of the following is to outline the categories and to assign them to areas in the offer-and-use model. In addition, the established categories should be supported by quotes from the interviews.

The *teacher personality* area includes all categories which have to do with the personality of the teacher. Categories could be identified which confirm the obstacles found in the literature and described above. For example, there are obstacles in terms of the context of a modelling task. Some teachers appear to be held back by the unfamiliar contexts in modelling ["…how on earth am I supposed to know that? I didn't study biology! I'm certainly not going to add a task to that."]. Another obstacle appears to be the amount of preparation time needed ["I recently had a really good idea for a modelling task. I spent three hours working on it until I was satisfied with it. I simply can't do that for every lesson. After all, I have 6 teaching hours to prepare for every day."]. The belief of some teachers that modelling makes the lesson too difficult for the pupils could also be confirmed ["The pupils had no idea what they were supposed to calculate. This isn't surprising when so much information is missing!"].

However, it is worth noting that these same aspects represent not only obstacles but also motives. For example, some teachers appear to regard an unfamiliar context as a challenge ["What's really exciting is what I learn myself in the process!"], and others see in modelling an opportunity to gain time in terms of the preparation ["I just cut out a newspaper article, think of a suitable question to go with it and I'm finished."], apparently holding the opinion that modelling requires less time to prepare. For this area new aspects could also be discovered which have so far not been mentioned in the literature. According to some teachers, modelling appears to require an increased level of flexibility ["I do try to think about which ideas the pupils could come up with, but it's not possible to predefine all the directions they could go in. Sometimes they ask questions I don't know the answers to myself, and suddenly the lesson takes a quite different direction to the one planned."] The role of the teacher, which changes when using modelling tasks, was regarded by these teachers as a positive role ["The pupils only really call on me when they're lost. Otherwise I can just take a back seat and observe them; the atmosphere is very relaxed."].

In the area *lesson quality* two categories from the literature could be confirmed: some teachers criticize the fact that there is insufficient availability of materials.["At the moment we are looking at functions, and for this I took the task with the bridge. And then another one … and another. But I can't always do bridge tasks; it's too boring for the pupils. But there aren't any other tasks for functions."]. In addition, one's ability to plan the lesson is negatively affected as it is more difficult to predict the way in which the lesson is going to go with modelling. Moreover, three new categories could be assigned to this area: first, teachers appear to regard modelling as being very complex ["The tasks are just too complex for the pupils; they feel really overwhelmed."]; second, as well as the time factor being a problem in terms of the preparation for the lesson, time was also cited as an issue for the actual lesson, as some teachers feel that modelling tasks are very time-consuming [“I haven’t done any modelling recently because quite simply there isn’t the time. When I decide to use modelling tasks, I need more than an hour. Perhaps two, or even better, three. But I don’t have the time.”]; third, concerning methods, both positive and negative aspects could be named, with some teachers holding the view that modelling tasks offer a huge variety of methods [“I can apply absolutely loads of methods; and besides, the pupils are then much more motivated.”], whereas others held exactly the opposite view, claiming that modelling tasks are in terms of methodology extremely difficult to design [“I have no idea which methods I should use for these tasks.”].

In the area *individual personal background,* the category ‘pupil motivation’ could be corroborated. Here, too, as corroborated by the literature, there appear to be two forms of this aspect. Several teachers hold the opinion that pupils are more motivated when doing modelling tasks [“The pupils find the practical work in modelling tasks really interesting. Then they’re fully motivated and have much more fun.”], while others claim that standard, traditional calculating exercises are more popular [“The pupils come to me and ask when we can do normal tasks again.”]. Three further categories could be established: some teachers believe that when doing modelling tasks pupils are more creative in their thinking and calculating [“The pupils have really good ideas that even I wouldn’t have come up with.”]; some teachers are convinced that modelling tasks lead to greater independence in the pupils [“The pupils work much more independently.”], which they view as being a highly positive aspect; and there is the question of the difference in abilities within one class. Here, again, opinions go in two opposite directions. A section of the teachers hold the view that modelling should not be applied in a class where there is too big a difference between the various abilities [“The weaker pupils freeze up even more and the stronger pupils are bored because there isn’t much calculating to do.”], while the others would appear to disagree with this view, arguing that it is exactly then that modelling should be used [“The weaker pupils tend to get lost less and are also more motivated. The stronger pupils can try out new ideas, taking more and more parameters to make the calculations more complex.”].

The area *context* stands for the basic conditions. The influence of colleagues and parents plays a significant role. And here, too, it appears to go in two different directions, which can also be found in the literature. Concerning the cooperation with colleagues and/or parents, the experience of teachers seems to be either good [“I asked the parents at parents’ evening to work out one of the modelling tasks, and after that they thought it was really good!”] or bad [“The parents? They don’t support it at all! They want me to set tasks like the ones they had at school.” Or: “My colleagues are all quite old and they’re not going to change things in their classes now. If I start talking about modelling tasks, they just smile at me patronisingly. So there is no cooperation at all."], both sides obviously having a very different effect on the use of modelling.

The area *effects* describes effects which can be attained from the long-term use of modelling. Here, all of the motives named in the literature and described above could be confirmed. Teachers appear to be aware of the positive effects modelling seems to have. It was also corroborated that teachers consider the measuring of performance as regards modelling somewhat problematic, as it would seem to be more complex ["I found it really difficult to assess the results. One of the pupils perhaps only guessed but got the right result; the other carried out a really complicated calculation but made a mistake. How can I assess that fairly?"]. A new category is the efficiency of the lesson. Some teachers see a more efficient lesson through modelling ["It is quite simply more efficient, because every pupil can contribute to these tasks. The pupils are all constantly occupied when they are modelling. And besides, they can remember the content of the lesson much better when they are actively involved, for example when they have had to measure the playground."], while others claim to see quite the opposite. ["I can't really afford to do modelling in my lessons, as it means giving up so much of the exercises."]

This list shows that as well as the reasons for and against modelling named in the literature, further relevant aspects are to be found. It is interesting that the very same aspects that are viewed positively by some teachers are viewed negatively by others.

PERSPECTIVE

By the end of the year, the data collection from the questionnaires and interviews will be completed. This should provide more information on the obstacles and motives, also highlighting any changes that occur to said obstacles and motives in the course of the further training. The question is whether in the process it will be possible to identify certain types of teachers.

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