

A New Start into Mathematics: A Project Concerning the Education of Mathematics Teachers for Primary Schools in Germany

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The education of teachers in mathematics consists of two parts: enhancing the math-skills of the students and education in didactics. Mainly the math is taught in lessons for 50 to 100 students or even more. This has wrong influence to the teaching style and the attitude towards mathematics.

This paper reports about a project, where active schoolteachers are involved in teaching the mathematics content. This is done in workshops, where the teaching can be a model for teaching a class. In addition there is the chance to inspire the students for mathematics.

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1. INTRODUCTION

The education of mathematics teachers consists of two parts: the mathematical content and the didactics of mathematics (*cf.* Ziegler, Weigand & a Campo, 2008). The intensity of the mathematical education heavily depends on the grade the teacher will teach in the future (*cf.* Brunner *et al.*, 2006; Dubberke *et al.*, 2008). A primary school teacher has not to learn as much mathematics as a high school teacher (*cf.* Bender *et al.*, 1999). The

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second part of the education is didactics. In Germany the education for these two parts are separated (*cf.* Hartmann *et al.*, 2000; Song, 2004) and it is not the aim of this project to unify both parts. We put the focus on teaching the content that is needed by primary-school teachers. This part of the education is mainly done by university teachers, who have no or only little insight into the reality of today's primary schools. The curriculum they follow is orientated to mathematical subjects and their structure: algebra, analysis, number theory, etc. But students for primary schools are only little interested in the content (Lilitakis, 2009). They want an education that gives them the ability to work with children. Our own research shows, that their attitude to mathematics is fair: they want learn content that is connected to the mathematics in the classroom, but mainly they refuse to learn mathematics for its own sake.

The lectures for these students are mainly held to an audience of 50 to 100 persons or even more. In such a situation the single student cannot be actively included in the learning process. Learning in such an environment is a passive task and contradictory to the approach to learning as a constructive process. So the student, becoming a teacher, gets wrong models for teaching. On the other hand this learning by experience has a strong impact (Cooney & Wiegel, 2003):

“Teachers teach as they were taught, not how they were taught to teach”

So there are two fields to change the education of teachers, not only primary school teachers: the content they have to learn and the way they learn.

2. THE GOALS OF THE PROJECT

According to the introduction there are two goals:

Goal 1: Constructing a new curriculum at university for teaching the content of mathematics

Goal 2: Setting up a new methodic approach, so it can be a model for the teaching process in the classroom.

The project is funded by the “Deutsche Telekom-Stiftung” and according to the contract we work on the first year of the education of the students. Of course it is one of our future goals to extend the described way of teaching to all three years of the study (BA: Bachelor of Arts).

Goal 1: Constructing a new curriculum

The university curriculum has to be orientated to the curriculum for the schools. The

teachers should learn the mathematics they need at school—of course not at the same level but from a higher viewpoint. In the first step of our development we have listed and analyzed the curriculum of primary and middle school (grade 1 to 10). In the next step we have clustered the subjects to find those, which are repeated in several grades. These are the key subjects. According to the standards of the German “Kultusministerkonferenz”¹ we have got for the primary schools:

- Numbers and operations
- Space and shape
- Patterns and structures
- Quantity and measurement

For middle schools you find the same key subject, but in addition there is ‘functions’.

In this collection of subjects the item ‘data and probability’ is skipped because there is a special lecture for this in the fourth semester (according to the curriculum at the University of Bremen).

Then we looked at these key subjects from the university level. You find “numbers and operations” in elementary number theory, “space and shape” in geometry and “patterns and structures” in algebra. To this we added topics, with which we have worked so far in teacher enhancement projects in Florida, US², and Germany³. From this experience we formed six main topics. The essentials of these topics to be chosen had been:

- They offer more than one connection to mathematical subjects and integrate an algebraic and a geometric approach,
- They are connected to at least one key subject (see above), and
- They foster the use of technology (standard computer software like spread sheets and dynamic geometry software)

This analysis led to the construction of seven main topics:

- Platonic solids,
- Place value systems,
- The golden ratio,
- Pascal’s triangle,
- Mapping of function graphs,
- Dimension, and

¹ (From Wikipedia) The **Kultusministerkonferenz** (literally *culture minister conference*—state conference on education and media) is the assembly of ministers for education of each Bundesland (federated state) in Germany.

² See http://math.fau.edu/Teacher/Teacher_homepage.htm

³ See <http://www.bnmc.uni-bremen.de/>

- The Arbelos (a very fruitful geometric structure).

These main topics had become the titles of workshops. For organizational needs we had been forced to have only six, so we merged 'Golden ratio' and 'Pascal's triangle' into one.

These six workshops are the core of the new curriculum for the first year at the university. To this we added a lecture (two lessons a week) to teach the theoretical parts of the curriculum. The content of the lecture comprises:

- Logic and prove
- Mathematical induction
- Combinatorics
- Sequences
- Basics of geometry
- Basics of functions

Goal 2: Setting up a new methodic approach

Usually the mathematics is taught in lectures, held to a large audience. In Germany it is common that there are around 100 students or even more in a lecture hall listening to a lecturer, who is speaking and writing at the blackboard for one and a half hour. The students listen, write down what they see on blackboard and, if they are quick enough, add some comments of what the lecturer is talking. All in all it is a passive way of learning and it is a misleading model of good teaching. Rarely modern didactics or new results and insights in teaching-learning processes are used.

Again, from our experience in former projects we knew that a much better teaching-situation can be reached, if you

- form small groups for workshops, where each student can be involved into the learning process
- let teachers, who know different methods of teaching from their all day work, lead the workshops (teachers teach teachers)

In the workshops the teachers will teach new content to the students, content that is connected to school mathematics, but the approach is from a higher perspective. It is important to us, that the teaching environment is set up in a way, that the students

- are actively involved in the learning process
- use different ways and styles of learning (exploring examples, discussing in small groups or with all etc.)
- build and use material (*e.g.*, 3D-models in geometry)

- work with computers
- present their results to other students

Of course there can be also phases, where a teacher presents something to the whole group. But even then it is much easier to ask questions and discuss something.

All this aims at giving the students models how they can organize their teaching in the future. It is a sort of teaching didactics although it is not the explicit goal of this part of the education. But you have to be aware how you organize it as every teaching is teaching didactics in the way that it gives a model for a teaching process. We think, that this aspect of the teaching process, which works unconsciously in the background, was underestimated in the past.

3. THE IMPLEMENTATION OF THE PROJECT

According to the aim to take teachers as leaders for the workshops, the first step in setting up the project was to find some, who are motivated and able to do the job. That means

- To learn the mathematical content for two main topics,
- To prepare the teaching material that is needed for the workshops, and
- To do the teaching to the students.

The ideal configuration for teaching a workshop is a team of two teachers, one high school teacher and one primary school teacher. Such a team is to our beliefs important: the high school teacher knows, from where the students are coming, what the fresh students learnt at school in the last year. The primary school teacher knows the realistic situation in his/her school and of the pupils. He/She brings in the world to where the students want to go.

To be on the safe side and as we planned to split the students into three groups we started with nine teachers: two high school teachers, three middle school teachers and four primary school teachers. Fortunately during the first two years we didn't lose any of them so that we are up to now in the comfortable situation of three teachers per group.

The process of preparation is shown in Table 1, covering the first two years. The timetable for the third year of the project (2009/10) is Table 2.

Table 1. The process of preparation covering the first two years.

First year	Second year	
Constructing the main topics for the workshops Teaching the teachers	Preparation of the material for the first workshop of each team	Teaching the workshop in the summer semester

Table 2. The timetable for the third year of the project (2009/10)

Third year	
Winter semester	Summer semester
Preparation of the material for the second workshop of each team Teaching the workshop to the students	Revising the material for the first workshop, same as last year Teaching the workshop to the students

4. THE ORGANISATION OF THE TEACHING

Usually a (big) lesson consists of four hours of lectures and two hours of training per week. As we wanted to reduce the theoretical approach in the lectures to increase the time for practical work in the workshops, we changed the timetable to two hours for the lectures and four hours for the workshops.

The teachers shouldn't learn and prepare all six workshops but should become specialists for two of the six workshops, one for the winter and one for the summer semester. But then it is not possible to teach the same workshop subjects to all students at the same time. We had to construct a plan for the sequence of workshops for the student groups (see Table 2). Parallel to the workshops a lecture is given. The content is listed above (Chapter 2).

Table 3. Organization of the workshops during the whole semester

Lectures		Two hours per week lectures for all students during the whole semester (14 weeks)		
Students Workshops	Group 1	Workshop 1	Workshop 2	Workshop 3
	Group 2	Workshop 3	Workshop 1	Workshop 2
	Group 3	Workshop 2	Workshop 3	Workshop 1
		← 4 weeks →	← 4 weeks →	← 4 weeks →

5. FIRST RESULTS

After a period of intense training and preparation (August 08 to March 09) we started teaching in the new way in the summer semester (April to July) 2009. The student group is for an evaluation special, because they knew both ways: the old one from the winter semester 2008/09 and the new one from the summer semester 2009. In an opinion survey the students were asked to give their impressions (advantages/disadvantages) to both semesters (free form answers). Nearly all appreciate the close connections to school and the hands-on approach in the workshops. They could easily follow the workshops and had the impression to learn something what they can use for teaching at school. They also appreciated the lecture. A critic about it goes to a high speed in presenting the content. Critics about the workshops mainly mentioned the cooperation between the different parts of the project (workshops and lecture) and coordination problems, partly among the three teachers of one workshop.

It is true, that the situation to teach in a team and to closely coordinate the teaching to that of other teachers is new to all persons of our team. Mainly all, particularly the middle and high school teachers, are used to work for themselves. They rarely have to coordinate their teaching closely to other teachers, let alone to teach with others in a team in the same classroom. It takes time and experience to get used to this new situation.

One success was the final exam to this unit, a written test for three hours, covering mainly the summer semester but also central subjects of the winter semester. 8 of 43 participants fail the test but have a second chance in a few weeks. It is expected, that in the end about just 10% failed this course. The drop out rate in other mathematics lectures in the first year is tremendously higher. In addition we have about one third of good or very good test results.

All in all, this unit in mathematics has:

- given the students an increase in mathematical knowledge
- encouraged them to proceed with their study
- given the conviction to learn for their future profession
- smoothed the big step from school to university

This report is a picture of work in progress. We can see early success and realize some shortcomings. Fortunately we have one more year to work on it.

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