COMPETENCE IN REFLECTING – AN ANSWER TO UNCERTAINTY IN AREAS OF TENSION IN TEACHING AND LEARNING PROCESSES AND TEACHERS PROFESSION

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Teaching and learning processes and the teacher's profession are afflicted with tensions of conflicting goals. After giving an outline on these areas of tension, the competence in reflecting will be suggested as an answer to the question on how to deal with tensions. Reflection support teachers and learners in bearing the often unsolvable tensions. The article then suggests facilitating actions in university education by integrating reflection tasks in teacher's education. Examples of students' reflections and first analysis results in changes of student's beliefs are given.

Keywords: reflection, tension, teaching, learning, process

THE SITUATION OF TEACHERS IN LEARNING PROCESSES

In Mathematics teaching and learning processes (prospective) teachers often experience uncertainty in dealing with conflicting situations. They feel lost in having to deal with contradicting interests. Prospective teacher students tend to search for „simple answers" - not for vagueness in decisions on how to set up and manage the learning process, to get the „one solution" on deciding how to teach, trying to step on one side of the contradicting poles of areas of tensions. This tendency is quite understandable as teaching and learning processes challenge teachers on a wide range of diversity: heterogeneity of primary school students shows in social and cultural background, literacy, language, interests, gender, skills, effort and achievement ability, and many more. In addition to those already demanding aspects (prospective) teachers are challenged to fulfill high expectations of school administration in their teaching and pedagogical actions. Modern teaching methods and a strong orientation towards the learning-outcome and competences leave (prospective) teachers often helpless.

The areas of tension are already coining the university studies and some of them are just lying in the nature of mathematics. Mathematics is presented strongly product-orientated as an elaborated theory which leaves no space for individual ways of thinking. Moreover it is actually just the power of mathematics being a product with clearly outlined rules and structures. But learning processes start at a totally different point. Students activate their pre-knowledge and try to connect to the mathematical concepts, what hardly turns out to happen in a straight way and nor getting to the intended rules. Teachers have to and should support this process, but often struggle in that area of tension. Both sides are important, having an individual conceptualization and the conventions, and it seems difficult to set up a balanced learning environment.

The answers from first year students at University of Siegen who were asked in a survey 2010 about their opinions and experiences with mathematics and their expectations of their studies reveal an image of mathematics and learning processes which can be characterized by putative conflicting interests and traits of mathematics, which tend to become even more diffuse during university studies. From this opinion and mood of students the areas of tension could be drawn: students enrolled for mathematics educational studies come with a strongly closed view on mathematics and the teaching and learning processes due to self-experienced classroom action. Their view is affected by conventions and rules, strongly regulated learning activities, which leads to internal tensions if the (prospective) teachers simultaneously reach out for more real life applications and comprehension orientated activities, clearness and more openness in teaching mathematics. The survey was used to extract some main areas of tension from students in mathematics training. The extracted areas of tension correspond well to my observations in university lectures and in mentoring teacher students in their first practical experiences at school.

These areas of internal tension, which afflict educational studies students and teachers, could be grouped in five classes (see Helmerich, 2012), given here by stating the extreme poles of tensions:

- form and content
- openness and closeness
- rigour and intuition
- product and process
- singularity and regularity

These concepts are the result of a survey among first year students in year 2010. The students were asked to describe their view on mathematics and teaching and learning processes with their own words. Basis for the clustering of the students' answers was the work of Krauthausen and Scherer (2007) on the foundations of teaching mathematics as "at first contradicting extremes" (translated by MH). The extreme poles mentioned by Krauthausen and Scherer (2007), like application orientation versus structure orientation, student orientated versus subject orientated teaching, individual ways of solving problems versus conventions, open tasks versus closed-ended problems link quite well to the areas of tension identified of the Siegen research group and mirror the results of the prospective teachers survey. I focused rather on the mathematics-related aspects of the "contradicting extremes" of Krauthausen and Scherer instead of the more general pedagogical ones.

Although we know that teachers encounter conflicting situations, and their professional knowledge and necessary competences are extensively discussed and investigated, studies like TEDS-M still describe areas of tension as a liability for teachers, but not the great potential of activating these tensions in the learning processes. Helsper names it "constitutive professional antinomies of teaching" (Helsper, 1996, 2004) (translated by MH), "which entangle the uncertainty of

representative interpretation and the simultaneous aspects distance and proximity." (Baumert & Kunter, 2006, p. 471) (translated by MH).

> "Taken the antinomious structure of teaching seriously, teachers necessarily will have to make decisions about their actions in teaching, which cannot be in accordance to both conflicting claims of validity at the same time. This situation will only turn out to be bearable and productive, if there is a working agreement of their free will" (Baumert & Kunter, 2006, p. 471) (translated by MH).

Among many areas of tension the five mentioned above are vital in mathematics education of our students – relating to their image of mathematics and their issues in learning mathematics – and seem to be characteristic for the nature of mathematics. Many other areas of tension could be brought into consideration, but most of them are rather on a pedagogical level and apply entirely only to classroom interaction but not to specific learning processes in mathematics.

REFLECTION IN AREAS OF TENSION

The experience in teacher education is that many university concepts do not spring into action in school teaching. One reason might be the strong beliefs built up over years during school which could hardly be affected by university teaching and breaks through under pressure in school teaching situations. So we set up a couple of actions in university teaching to form at least some awareness of the students beliefs, make them reflect on their own beliefs and attitudes towards mathematics, teaching mathematics and the learning process of mathematics.

Teaching mathematics does only work in areas of tension, teachers have to make decisions, have to hold on these conflicts lay out in the nature of mathematics, in the clash of own standards and environmental restrictions. In order to stand these tensions, and to achieve "mathemacy" (Skovsmose, 1998, p. 199), which is "more than an ability to calculate" (Skovsmose, 1998, p. 199), reflection competence is required.

Before showing examples for these reflection tasks and what students made of it, the term of reflection, as it is used here, is explained. The American Heritage Dictionary [TAHD] gives the following definition on reflection:

> "1. The act of reflecting or the state of being reflected. (…)
> 3. a. Mental concentration; careful consideration.
> b. A thought or an opinion resulting from such consideration." (TAHD, 2009)

This definition points to important aspects of reflection: consideration of your own actions and thoughts and come to an opinion on that. To reflect your own standards on learning processes, the reasons for your decisions and the origin for your belief systems (see Törner & Pehkonnen, 1995) is necessary to get over the uncertainty and learn to deal with it, accept it as a necessary state in which learning and teaching will happen.

> “Reflection means reconsidering what is taking place. Reflection is a mental, a conscious or a theoretical activity. In my terms: It is a critical activity and a process of grasping basic processes of social development. If reflexive modernization has mathematics as constituent, then reflections with respect to mathematics become of particular importance.” (Skovsmose, 1998, p. 200)

Reflection on opinions of prospective teachers towards mathematics and learning processes can oppose to uncertainty in areas of tension. The own positioning between the poles of areas of tension and knowing the reasons and justifications for the positioning must be learned and trained already at university.

A REFLECTION PROJECT IN TEACHERS EDUCATION

This section illustrates how reflections and reflection competence could be encouraged and facilitated in university education for prospective teachers. Examples of reflection essays from students are used in a case study on reflection competence. In this paper a first attempt of a theory orientated analysis of these essays is given by using Skovsmose’s dimensions of reflection (see Skovsmose, 1996, 1998) as a framework for analysing the statements of the students. Further research on the development of reflection competence in teachers training by writing reflection essays will follow. So far the aim of this project was to get students to a reflected position of their image of mathematics and how to learn and teach mathematics at school.

In the beginning of the project accompanying a lecture, occasions of reflecting were integrated, to start off with just describing opinions on material presented in my lessons, and to continue with writing tasks throughout the whole semester, provoking processes of reflection and enforce my students to take a firm stand on their beliefs, decisions and opinions in teaching and learning processes. The university course on “Learning Mathematics as Construction Processes” for third year students seemed to be the right place for starting with the reflection project. About 200 of the 350 enrolled students took part in the take-home reflection assignments which came in addition to the tutorial work and homework, included some kind of reflection tasks already as for example to discuss advantages and difficulties of different teaching settings or mathematics problems.

With the reflection assignments, shortly called „E-Reflex“, the teacher students are encouraged to reflect their own learning process and to comment on the presented contents, as reflecting is crucial for reasonable and sustainable learning und understanding. In this way of reflecting the teacher students got the possibility to express their observations and thoughts in order to become aware of their own learning process and issues. By working on the reflection assignments the mathematical and didactical content knowledge is engrossed and competence in reflecting is trained and elaborated. Moreover those E-Reflex texts gave me a good feedback on the learning progress of my students and enabled me to respond in

further lectures. The student texts had to be uploaded to a learning plattform "Moodle", were revised by myself and handed back with attached short comments. With these comments the students got a feedback on depth and width of their thoughts.

As a guideline for setting up the reflection tasks and an analysis and evaluation tool I adapted the theory of Skovsmose (1996, 1998), who differentiates several dimensions of reflection in mathematics:

- mathematics-oriented reflection
- model-oriented reflection
- context-oriented reflection and
- lifeworld-oriented reflection.

Usually these dimensions are used by Skovsmose to describe reflection processes of mathematical actions. For the E-Reflex project the aspects were applied for reflection on learning and teaching processes of mathematics. Mathematics-oriented reflection was transferred to didactics-oriented reflection, covering questions on the coherent usuage of specific didactical theories, stringent lines of argumentation and reasonable usage of didactical terms and concepts for describing phenomena in teaching or learning processes. The model-oriented reflection applies to considerations about the ideas of teaching and learning processes and their adequacy. Furthermore it asks whether a didactical theory or concept covers a certain idea or process, or whether an alternative conceptualization could be brought up. Context-oriented reflection gives insight to thoughts on learning environments and surrounding requirements, whereas the lifeworld-orented reflections should connect didactical and pedagogical thinking and action with individual beliefs and discussion of the relevance of didactical theories for distinct actions. The reflection tasks try to cover these dimensions and link them to concrete mathematical problems or classroom action considerations.

Besides giving a framework for the formulation of the reflection tasks, these dimensions of reflection are later deployed for the analysis of reflections of the students in mathematical educational studies. Since the reflection tasks are not focused on one possible answer, one need to have an analysis tool for differentiated evaluation and feedback processes.

The first E-Reflex task covered the didactical concept of learning by discovery, that is based on a constructivistic position. The students should reflect on the question whether mathematical discoveries of primary or secundary school students are possible at all, and if so to give an practical example, in which setting or problem discoveries could be made. In addition it had to be discussed, if there are specific mathematical concepts and contents which could not be learned by discovery. Last but not least the teacher students should state their preferred mathematical content for interrogative-developing teaching and teacher centered classroom action, and the reason for their decision.

In this first assignment the students had to reflect on possibilities for discoveries in mathematics, taking a closer look on mathematics in primary school in a mathematical-oriented way, but also with respect to pedagogical concepts and beliefs on how teaching might be. Student Kerstin wrote:

> "(…) In my opinion, almost everything can be learned by kid's own discoveries, assumed that one provides specific learning materials. Even concepts could be established by working on tutorial sheets. But I think it is good for kids, if you bring some variety to teaching and don't withdraw yourself all together. 'Let the kids just do their own thing' is not a healthy attitude in discovery learning.(…)" (translated student's text)

In order to reflect on the given question Kerstin has to make her own concept of teaching explicit, moreover she combines her experience and belief of good teaching with lifeworld attitudes and take up a position pro discovery learning. Most of the student's texts argued for discovery learning as an important principle in teaching, but some students expressed their tendency to go for teacher centered, guided learning methods if it comes to secondary school and putative more abstract and conventional mathematics.

The second E-Reflex assignment challenged the students to justify mathematics in school. With Heymann's claim that mathematical instruction should provide a general education (Heymann, 1996) and Winter's call for important basic experiences with mathematics (grasp mathematics as a certain way of looking at our world, experience mathematics as a structured, well-formed theory and as a certain way of thinking providing problem solving abilities) (Winter, 1995) the students got two positions during lecture to potentially set up their arguments. But the reflection task aimed on their own opinion and their individual justification for teaching mathematics in school, too. It was motivated to make their point of view explicit by giving practical examples or choosing only distinct contents out of the wide range of mathematical knowledge.

Most students argued with the aid of importance of mathematics for every day life, applying the dimension of lifeworld-oriented reflection. A typical sequence is found in Eva's text:

> "(…) Personally I think, that mathematics is sort of basic competence for social life in our culture (in the jungle of course appllies something else). But in our industrialized world mathematics is essential. Regardless whether it is shopping, work or leisure we will be confronted with mathematical topics. Some kids say things like: 'I wanna be a hair dresser, gardener or baker, what do I have to know maths for?' But you can easily find concrete examples for mathematical topics even in these jobs.(…)" (translated student's text)

The third E-Reflex problem was a rather mathematical-oriented task. The students were confronted with a supposedly „illogical spot" in mathematics. The students then had to understand, whats going on in this problem and complete a dialogue of two school kids talking about this thing and trying to figure out, how it works. By using

the dialogue setting the students had to think about the answers to the given problem, but also about difficulties in understanding the mathematical concept underlying the problem, so to think about both parts in the conversation. This method and its positive learning effects is discussed more deeply in Wille (2011). After writing the dialogue it was mandatory to reflect on this kind of task: How did it feel it to work on this assignment? What could be learned by doing this? Is this method a possible starting point for learning processes at school?

Working on this task the students experienced the constraints and opportunities of putting yourself in another's position. Many students found themselves struggling with the problem and so having difficulties to take over the explainig part in the dialogue. But they all acknowledged the high potential for learning and deeper understanding of mathematics throughout this reflecting way. Since the dialogues turned out rather lengthy and would have to be shown in reasonable large sections to grasp the line of argumentation, examples could not be displayed in this article.

In the last E-Reflex task, the students were asked to describe their idea of heterogeneity in classroom action and how they would deal with this diverse situation in teaching and why in this way. To carry it further on, a preference for teaching in a homogeneous (assuming this would be possible to form) or a heterogeneous class should be given. Insisting to take up a stance on the dialectics of learning processes is impoartant to really reach the students in their core beliefs and get a reflection process startet on this. A final remark should be made to outline possible actions of differentiation in learning processes and to discuss, if – assuming again that homogeneous learning groups could be put together – differentiation is actually necessary.

In the last task I have noticed a huge step towards a reflection competence in the student's texts. Almost all reflections turned out longer than the obligatory two pages and showed the effort of lay out the reflection in all four dimensions. The student got more confident in positioning themselves in areas of conflict demonstrated in sophisticated and deliberative lines of argumentation. Exemplarily the text of Diana shows the progress in belief changes:

> "(…) If I had been asked several weeks ago, whether I prefer a homogeneous over a heterogeneous learning group for teaching, I would have probably said yes. Because one cannot imagine anything better for a teacher than teaching kids who are all on the same knowledge level and learning the same content at the same pace and time. (…) The teacher would be able to plan teaching precisely and would cover all anticipated content. (…) I want to be a teacher actually just because of the variety and individuality of the students. Of course I want to teach a heterogeneous learning group. (…) The individuality of learners has to be exploited for a good learning environment." (translated student's text)

CONCLUSIONS AND FURTHER RESEARCH WORK

The reflection tasks were used in the course to enable prospective teachers to overcome their uncertainty in areas of tension by reflecting on mathematics teaching and learning issues, their own point of view and last but not least their options in dealing with conflicting situations.

This first review of the student's reflections is encouraging for future reflecting projects in university's teacher education since a development from uncertainty in teaching actions towards a reflected way of taking position in the range of possible actions in areas of tension is noticeable.

The reflection impetus of the assignments could be improved by stressing out even more the importance to have a look at both sides of the tension spectrum. Not only the positioning on one pole of the areas of tension, but the experience of opportunities and threads of the far ends and the ability to find your place somewhere in the middle in many situations, not being able to make an easy decision for one side but instead having to bear with the tension, is a desirable goal in future reflection projekts. This will help students to establish a reflected way of knowing in which situation the decision for one pole is appropiate and in which situation you have to stand the tension.

In further research it is profitable to take a closer look on the student's texts and carve out types of reflection characters to achieve a deeper insight of persistence or approaches to changes in belief systems and thereby a better understanding of the effectiveness of university teaching on students.

This reflection projekt is linked to the broader research topic of the Siegen group, searching for objectives and educational goals and a curriculum for mathematics teachers (see Lengnink, 2011; Helmerich, 2011). With those objectives the competences in mathematical repertoire (content knowledge in mathematics), attitude on and to mathematical content and the observable performance are combined to an education framework. In this framework reflection links repertoire, attitude and performance together by defining the relation between the triplet: education manifests in a reflected attitude on a mathematical repertoire which implies performances in teaching and learning processes.

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