IMPROVING THE MATHEMATICS CLASSROOM CULTURE THROUGH SELF-REFLECTION

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Abstract. *The cultivation of teachers' self-reflection and the systematic use of collective reflection can change the character and promote the quality of personally- oriented education. Therefore, we aim at creating suitable conditions for promoting reflection. In this paper, we will show how a selected group of primary school teachers perceived and evaluated their competences in the course of preparing, carrying out and analysing several teaching experiments. The paper is based on samples of teachers' reflections.*

Introduction

A significant feature of the present time is the drive to change the character of education. It seems that an opportunity has arisen for a paradigm shift to the humanistic perspective, to personally-oriented education. There is a demand that education should adequately develop the student's abilities, potential, and skills. Education should „enable students to keep their potential up to date, to express their efficiency, and to cultivate their sociability" (Helus 2001). That is, that education should pass from the mere transmission of information, instructions and recipes in the teaching/learning process to cognising, experiencing, acting, communicating, and living together, and should develop a thirst for self-education. Personally- oriented education facilitates an integrated view of the world and of the human being's place in it.

We investigated the above issues in the framework of projects supported by the Grant Agency of the Czech Republic (GACR) under the titles „The Parallels of Gaining Knowledge and Educational Processes in Mathematics" and „Student-Focused Mathematics Education". Early in our investigation, it transpired that both the character of mathematics classes and their quality depend to a decisive extent on the teachers, in particular on (a) what their beliefs are about the sense, meaning and substance of mathematics education, (b) how they are prepared to teach in terms of content and methods, and (c) what the teaching activities in their lessons are. Therefore our attention turned to the teacher and teaching. (When speaking about the teacher, we do not have in mind only her/his theoretical knowledge of mathematics, didactics of mathematics and teaching methods. We also mean the teaching activities used in mathematics lessons and the teachers' reflections on them.)

We came to the conclusion that if we want to change the character of teaching (mathematics), we should aim above all to influence the teachers, to develop their attitudes, opinions, beliefs, teaching activities in mathematics lessons, their ability to act as creators of a friendly and favourable climate, and as vehicles for challenges. We should aim to improve their theoretical capability as well as their practical teaching competence.

Our ideas correspond to the general ideas of the distinguished Czech educationalist, Z. Helus: „A successful effort to change the school is only possible if the teacher becomes its leading agent. It is to do with answering questions regarding his/her competences and responsibility, regarding his/her appropriate good condition, regarding updating his/her pre-service preparation and providing lifelong education." This implies a change in the demands on the teacher's knowledge and competences. The basic competences that form the basis of the teacher's self-confidence include the following:

(a) Competence consisting of (1) creating conditions for the development of students' prerequisites by the effective organisation of educational influences, by motivating students' own educational activities and by exploiting their potential, (2) removing mental blocks and barriers, (3) mastering diagnostic operations, (4) getting an insight and empathy, and (5) designing procedures for effective pedagogical intervention.

(b) Subject-didactical competence, consisting of skilled orientation toward the educational meaning of teaching a specific subject, and putting this into action in relation to specific students. This competence encompasses mastering the scientific basis of teaching a subject, as well as didactical creativity (i.e., the ability to keep the subject matter up to date in its cognitive, motivational and social significance).

(c) Pedagogical-organisational competence, consisting of skilled orientation of control of the relations and activities in the classroom aimed at creating an effective educational environment, together with a supportive and stimulating climate.

(d) Competence in qualified pedagogical (self-) reflection, with emphasis on analysis of the teacher's own thinking, and dealing with students in a way suited to their ability to plan their own lifelong education.

K. Krainer (Krainer 1996) in his paper at ICME-8 presented four dimensions describing teachers' professional practice:

„Action: The attitude towards, and competence in, experimental, constructive and goal-directed work;

Reflection: The attitude towards, and competence in, (self-) criticism and one's own actions systematically reflecting work;

Autonomy: The attitude towards, and competence in, self-initiating, self-organized and self-determined work;

Networking: The attitude towards, and competence in, communicative and cooperative work with increasing public relevance.

... Each of the pairs „action and reflection" and „autonomy and networking", expresses both *contrast and unity,* and they can be seen as complementary dimensions, which have to be kept in a certain balance, depending on the context."

K. Krainer goes on to warn: „One could say: *there is a lot of action and autonomy but less reflection and networking*, ...“

In this paper, K. Krainer gives some reasons for teachers' lack of reflection and networking: (a) the cultural and historical background; (b) no place for reflecting or networking in teachers' pre-service or in-service education; and (c) „reflection on one's own teaching and sharing it with colleagues is unusual, and costs a lot of time and effort.“

Problems around the role of introspection, self-reflection and collective reflection are one of the main areas of research in present-day mathematics education and in didactics of mathematics. It also manifested itself in the proceedings of group III and IV at the CERME 1 and 2 conferences (Schwank, ed. 1999; Novotna, ed. 2001). For example, Climent and Carrillo (2001) indicated that "... the most important thing is to make available opportunities for reflection on one's own knowledge and beliefs, this being a possible point of departure for a change chosen by the teacher".

In our opinion, the competence of qualified pedagogical reflection (self-reflection and especially „collective reflection“) of everyday teaching is very important. In the text below we will refer to "reflection". We are convinced that systematic reflection can bring about a significant improvement in the teaching/learning process. However, in the Czech Republic, much less attention is paid to any form of reflection than its importance would justify. This is in contrast with the results that we have obtained from our research in the framework of the GACR projects. For most teachers and also researchers, reflection goes on at an intuitive level. Some teachers make notes (pedagogical diaries), but they have not been made aware which phenomena they should observe, how to assess and evaluate them, which information they can gain, or how to use it for the improvement of education.[1]

The Comenius Project

Since 1999, we have been cooperating with German and Italian colleagues within the Socrates Comenius project „Understanding of mathematics classroom culture in different countries“. The aim of the project is to improve the quality of continuous in-service education of primary school teachers via changing the character of teachers' work in the teaching of mathematics. From the beginning, the key feature of our project has been the participation of primary school teachers and teachers from universities involved mainly in pre-service teacher training. The team will prepare an in-service course for teachers from different European countries. In the original proposal of our project, we aimed to work on a description of classroom culture and its characteristics (Seeger, Voigt, Waschescio, 1998). We formulated our aims and objectives as follows:

[1] Quite recently, some didactic research in this field has appeared. Students' introspections are included in their diploma and doctoral theses. For instance, Stehlikova (2002) shows the use of student introspection as a tool supporting her development as a problem solver and a teacher-researcher.

The aim of the research is to understand specific features of mathematics classroom culture in the participating countries. Therefore we will aim at:

- describing and analysing these general characteristics in each participating country,
- finding the most important phenomena in the classroom and relations between them,
- investigating their importance for building a classroom culture,
- assessing their influence on the process of education,
- evaluating their benefit for the results of education, and
- considering the educational tradition and circumstances to judge the possibility of transferring and the most effective and powerful of the mentioned characteristics into education and utilising them in other (participating) countries.

The results of the investigation will be elaborated and included in the materials for in-service teacher training. The materials will be implemented in practice and tested in each participating country within small groups of teachers. An impact is expected at the practical as well as at the theoretical level. The results will contribute to knowledge concerning classroom culture and its influence on various aspects of mathematical education."

Our original conception was that we would observe the content and teaching methods in the course of mathematics lessons in the participating countries and show the differences in the approaches to the teaching, in particular of the cooperating countries (a) in general, and (b) in certain mathematical topics. Our intention was to look for inspiration in approaches to education applied in other countries, and possibly to observe how the same mathematical topics (that the whole team agrees on), will be didactically elaborated and taught in each of the participating countries.

The beginnings of the work in the Czech team were "constrained". After two years of work within the project, we asked the teachers to write what their expectations, profits, and advantages from the project had been. All of them wrote something like: *"At the beginning, I had no idea what I was expected to do." "I was afraid." "I was afraid of the language barrier."*

We started by discussing what we mean when we speak about "classroom culture" and "mathematics culture". We did not aim at a "precise" formulation because we supposed that this notion would gradually be grasped. This expectation was confirmed. We then considered how to select a mathematical topic and clarify the mathematical background of the selected topic and its possible didactical elaboration.

Then the teachers prepared teaching episodes within the boundaries of: "what I consider important", and "what I would like to show to children in my classroom". The lessons were videotaped and the video recordings were evaluated in consultation with the participating teachers.

In order to fulfil the project aims and present our results in a joint workshop of the whole international project team, we chose, following the teachers' suggestions, the episodes below, which are, in our opinion, suitable and appropriate for illustrating classroom culture in the Czech Republic.

We originally presumed that we would focus our attention on the content and teaching methods that arise from the educational tradition of each participating country and on the understanding of "what" and "why" and "how" the topic is taught. In the course of the discussion with our colleagues from Germany and Italy during the meetings of the whole team, our attention gradually shifted. The grasp of the project questions by our teachers and researchers gradually changed, too. Our view, initially broad gradually developed and was refined. We further specified our previous aims and focused on teaching activities in mathematics lessons.

Our teachers themselves suggested that, in our further work on the project, we should organise more frequent discussions of the whole Czech team and jointly reflect on all parts and phases of the experimental work. It was clear to us that qualified pedagogical reflection (as we understand it) required joint preparations for lessons, making videotapes, participating teachers attending each other's mathematics lessons, joint evaluation, etc. (Steinbring 2002), and that it is necessary to prepare the teachers for such activities.

The aims of the Czech part of the project team were: (a) to improve teaching via teachers' reflection, (b) to form more sensitive teachers' approaches toward students' ways of thinking, and (c) to produce moments valuable from the point of view of students' cognition, to create a sense for such moments and the ability to make use of them.

The teachers started to participate actively in the preparation and evaluation of the experiments. That is, in the course of the research project they are acting not only as teachers but also in the role of students or researchers. They are also much more deeply engaged in the preparation of new experiments.

Case Study – Teaching Episode

In the preparatory phase of the teaching episodes, all teachers preferred to show something non-traditional in the Czech school, even if they realised, as teacher "A"[2] expressed it: *"All teachers fight against the stereotypes and traditional, repeated ways of teaching."* The preparation of all teaching episodes proceeded via discussions within the whole team (teachers & researchers). The teachers devoted their attention mainly to the motivation of the children, to the organization of their work and to the methods of education. The researchers concentrated on the mathematical and didactic backgrounds. We developed several teaching episodes. Here, we will present one of them – concerning equal sharing as the preconception of fractions in the 1st grade.

[2] Instead of the real names of the participating teachers, we will use: Teacher „A", Teacher „P", Teacher „J", Teacher "K".

After some discussions, the context of a "garden" was chosen as a natural environment for equal sharing. The teachers planned three main steps in the proposed lesson: (a) equal sharing in a continuous environment *(Divide the flowerbed into two equal parts),* (b) equal sharing in a discrete environment *(Plant the seedlings),* (c) discussion on different solutions and explanations for them *(What were we doing?).*

We do not want to analyse the course of the two lessons, but in order to understand the following comments, it is necessary to give some details of the actual work in the class. For task (a), the children were given a large sheet of paper. The teachers presumed that the children would share the paper by folding it. During the lesson, the children folded the paper very precisely. In the explanation (c), they were able to verify their solution again by folding. They were able to express that one part of the divided flowerbed is a "half". But it seems to us that for many children the word "half" is a synonym of the word "part" (when they divided, e.g., a cake into four equal parts, they said that they had four halves, and when they divided the cake into eight equal parts, they said that they had eight halves). For task (b), the teachers prepared pictures (models) of kohlrabi cut out of paper. The teachers asked the children to solve this task with the help of these models.

During the meetings of our team, we have observed changes in the teachers' attitudes toward the project and toward their own way of teaching. In our opinion, the quality of communication and reflections increased. Teachers' beliefs manifested themselves in their teaching and in their reactions during the joint analyses of the teaching episodes. Their statements refer to different teachers competences (in the sense of Helus, 2001). Let us introduce some of the teachers' statements, made in the course of discussions, together with our observations.

Samples of Observation

Despite the agreement among the teachers in the course of joint preparation, we expected differences in the execution of the teaching episode. What we did not expect were such great differences in the approach to the topic, its elaboration in terms of methods (subject-didactic competence), the form of organization in the classroom (pedagogical-organisational competence), etc. Despite the initial joint discussion and agreement, differences already appeared in the posing of the problems, as we will show in the following text.

Teacher "P": ***"I like my pupils to work and discuss things in groups."***

The conviction of teacher "P" was displayed during her teaching. Children – though 1st graders – in her classroom cooperated freely in the course of solving the problem. They addressed other pupils in the follow-up discussion. On the contrary, in the class of teacher "A", the children worked on their own although they were told to work in pairs.

Teacher "A": ***"In mathematics teaching I often use the children's practical experience and knowledge from other subjects."***

Despite the joint preparation, the formulation of the task "We plant the seedlings" differed considerably. Before setting the task, teacher "A" created an environment that promoted the division into equal parts, but she did not articulate that. The children worked out some exercises on the addition of equal addends. The teacher supposed that in this context children would create rows with equal numbers of seedlings. Moreover, the children had previous practical experience with growing green peas in the flowerpots in the classroom.

Teacher A 30. Imagine that your mother has one more flowerbed and some left over seedlings of violet kohlrabis in the garden. Do you know what to do with these seedlings?

The teacher prevented possible misunderstandings in the dialogue based on the practical experience of the children:

Teacher A 34. Will we put the kohlrabis in one stack? Verunka.

Verunka 35. No. We will line them up.

Teacher A 36. And why do we not put them in one stack? Michal.

Michal 37. Because they would not grow then.

Teacher A 38. Well, they need enough space to grow and light too. ….

Teacher "P" also formulated a practical problem according to the previous collective preparation but stressed equal sharing in the formulation.

Teacher P 24. I have one simple task for you now. I would like you to divide 18 kohlrabis that you have received into 3 rows. Do we manage to split these kohlrabis into three equal parts? I mean split into three rows in such a way that there will be the same amount of kohlrabis in each row?

Despite the fact that the children in each class were in fact solving different problems, some of the children's solutions (procedures as well as results) were the same.

Reflection

In both classes, the children discussed and explained their solutions. Different classroom cultures (teacher's beliefs, the formulation of the task, the way of argumentation, etc.) resulted in different levels of explanations of solutions and reasoning, both given by the pupils and accepted by the teacher.

Teacher "P", for example, initiated and accepted a performed activity (folding) as a sufficient explanation for halving.

Teacher P 72. Could you prove that it is correct? I would like somebody to prove it in such a way that he/she puts his or her hand on it and does something with it. ...

In situations where teacher "P" sought for the explanation in the language of school mathematics, she initiated the "mathematical" representation of the situation:

Teacher P 54. And Mí_a, how did you find that it is the correct part? That there is nothing

more to add? Patrik, how did you justify that to her? What did you tell her?

Patrik 55. 6 plus 6 equals 12.

In a similar situation teacher "A" only required finding the number: *"How many kohlrabis are there in one row?"*

A verification from the point of view of everyday life experience occurred only in the class of teacher "A".

Martin 55. I did it in such a way that they were not too close and had enough space and could grow.

Teacher A 56. You only placed them and tried. Do you like it, children?

Despite asking the last question, the teacher probably did not want to stress an aesthetic feature. However, in the following discussion, the children often used arguments like: *"I liked it that way, so I tried it.*" *"I laid them out nicely."* The question "Do you like it?" had been intended in the meaning: "Do you think that it is correct?"

Collective Reflection

In an explanation in the classroom of teacher A, a girl strengthened her point by "social" arguments:

Teacher A 111. How did you find that it is necessary to count in threes, Veronika?

Verunka 112. My grandmother taught me this. She told me if I only had one half of the paper, I should lay them out in threes.

Since the teacher did not comment on this, the next girl considered this argument and "everyday life" arguments as acceptable, and used them, too.

Teacher A 121. Maruska, how did you proceed?

Maruska 122. I put them into rows. I have rows like that in my flowerbed *(she points to the rows in the picture)*. My sister has them like this *(she points to the first horizontal row in the picture)* and like this *(she points to the last vertical row)* and they don't not grow for her like they do for me. And Grandmother taught us this way.

Teacher A 123. And how many peas do you have in one row? Show us, count them.

Maruska 124. Four.

Teacher A 125. How did you find that there would be four, not perhaps five or six?

Maruska 126. So that they did not jam so much.

Teacher A 127. You tried it, distributed them and just four fitted best.

In the course of the collective analysis of the video recording, teacher "P" noted that she probably would, in this case (after step 112 from the previous dialogue), ask the question: "*What would you do if you had 16 kohlrabis*?" And she added: *"I like*

provocative questions." Teacher "A" did not agree, because she was afraid of confusing her students too much. In spite of this, in her written self-reflection the following appeared: *"The follow-up discussions of the whole team are positive for me. I do not realise many things, they do not occur to me. Sometimes I do not have any idea to look for another way."* In our opinion, this statement demonstrates that this teacher thinks through all discussions.

Concluding Remarks

Although we are still in the middle of work on our Socrates Comenius project, we can already formulate some of our findings. As we have already mentioned, action-research as "systematic reflection of practitioners on action in order to improve it" (mentioned in Jaworski 1999, p. 206) is completely new in the Czech Republic. The investigation conducted so far suggests that reflection contributes to the answering of some questions concerning the teaching of mathematics and mathematics classroom culture. Let us present several of our observations.

Collective reflection has proved to be an effective way of improving teaching and teachers' competence in the subject (mathematics) as well as their teaching competence.

The teachers themselves say that collective reflection facilitates their personal and professional growth. Teacher K expressed it like this: *„I always thought (and my mother, who is an elementary teacher, confirmed it), that the best thing is „effect teaching". I mean a diversity of topics, methods, solving a great number of problems, etc. Now I think much more about the pupils' understanding and I aim at focusing more deeply on a single thing."*

At the same time the teachers point out that collective reflection is possible only in certain schools; understanding and support of the school leadership is necessary.

From mere performers of instructions and commands given by an outside researcher, the teachers became active participants in the course of all phases of the experimental work (preparation, execution, evaluation and assessment). They gradually changed their beliefs about the meaning and significance of collective reflection. In our opinion, their self-awareness also increased, especially when they saw that the whole team appreciated their thoughts.

The teacher's grasp of the importance of systematic self- and collective-reflection and of discussing their work with colleagues and teachers develops. This is documented, for example, by a statement of teacher "A": *"The video recordings, which are authentic, are excellent and allow me to observe my work from a different standpoint, from the position of an observer of the efficiency and quality of my teaching – verbalization, correctness and accuracy of formulation of the tasks, quality of communication with pupils."* Teacher "J": *"For me, the self-reflection and help of other colleagues are important. In some situations I would not be able to change by myself, even if I wanted to."*

Participation in the project supports the teachers' professional development and improves their competences as teachers. The teachers appreciated the possibility to discuss their teaching with other colleagues and to work on further self-improvement. Teacher "P": *"The opportunity to communicate about problems of teaching is a huge ´driving engine´ for me."* Teacher "J": *"Thanks to the project, I have an opportunity to see the teaching of mathematics more deeply ..."*

Awareness emerged that collaboration in an international team promotes collective reflection of teachers in one school, or teachers in different schools and even in different countries. It enables them to view their teaching starting from a classroom culture based on a different educational tradition. Teacher "A": *"I appreciate that I can recognize the differences in the culture of other countries. The culture influences the work in school and the whole climate in the classroom."* Teacher "P": *"I am convinced that the culture of education coheres inseparably with the culture of the nation."*

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Acknowledgements: This research is supported by Socrates project 87636-CP-1-2000-1-CZ-Comenius-C31 and GACR 406/02/0829.

We thank Mr. Robin Healey for his help with the translation into English language.