Changing classroom environment and culture

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Introduction

The view of mathematics which the student has built up during their school career, survives long after they leave school. The situation where mathematics is taught only as a set of precepts and instructions which have to be learnt leads to ever deeper formalism in the teaching of mathematics, resulting in a lack of understanding of the conceptual structure of the subject and an inability to use mathematics meaningfully when solving real problems (Novotná, 1999).

Cultivation of the student’s mental representation of world is possible only by deepening his/her active interest in the subject. It is commonly known how difficult this process is given the range of students’ attainment, the demand of the subject matter and the fact that student’s interest may not be naturally disposed to the subject. Teachers need to be mindful of the importance of the social climate within the classroom and the possible contribution to the quality of students learning.

1. Theoretical framework and related research

De Corte (2000) writes: “Recent research on learning and instruction has substantially advanced our understanding of the processes of knowledge and skill acquisition. However, school practices have not been innovated and improved in ways that reflect this progress in the development of a theory of learning from instruction”. Our paper is intended as a contribution to the broad discussion about learning and instruction.

In (Kubínová, Mareš & Novotná, 2000), four schemes subject matter – teacher – students were analysed and characterised: IR (instructive teaching method, direct teaching of ready information or learning from text), ID (instructive teaching method, attempt for students’ independent transfer of acquired knowledge), CR (constructive teaching method, learning from text), SC (social constructive teaching method). The main consequences of the use of constructive teaching methods are: The
subject matter becomes an intermediary which enables the development or modification of students’ existing concepts and the creation of new ones; social relations among individual cognising subjects are accepted; the role of the social relationship between students and teacher are accentuated, and the social relations among students are taken into account. Divisibility test were taught to 13 groups of students using the four teaching approaches IR, ID, CR, SC. At the end of the teaching experiment the students’ knowledge and understanding was assessed using unseen tasks, two of which were closed tasks, relying on procedural knowledge (i.e. skill acquisition), while two required conceptual understanding. All students performed similarly well on the procedural tasks but students from the two groups whose teaching was based on constructivist principles were more successful on the tasks which demanded the application of knowledge and understanding to unfamiliar contexts.

Social situations exist in the school regardless of the significance we give them (Kubínová, 1999). If an opening of the space for effective teaching is to occur, it is necessary to create more natural conditions for teaching, i.e. a situation which enables this to happen. The teacher should

- admit that they are not the only source of information for students, that discussions with other people, TV programmes and Internet access significantly influence students’ knowledge and way of learning,
- understand that each of their students creates their own concepts and these concepts are multilevelled with respect to the student’s own concepts as well as to their peer group, and that many of these concepts are not complete, sometimes even not correct but used by them for experiencing the world,
- suppose that students already created a certain concept through various resources, not only during the work in class.²

Several authors have studied the student-student discussion during the work in small groups (e.g. Hoyles & Dekker). Hoyles (1985) suggest that mathematical understanding is considered from a social interaction

² Similar ideas can be found already in the work of J.A. Komenský (Comenius).
perspective and regarded as the ability to form a mathematical idea, to reflect upon it, use it appropriately and flexibly, communicate it effectively to others and to reflect on other perspective or challenge and logically reject an alternative view. In (Dekker & Elshout-Mohr, 1998) a process model is used to focus precisely on the individual learning by examining the relation between the quality of interaction and the process of raising of understanding. This process model is constructed around the four key activities: showing, explaining, justifying and reconstructing one’s work.

Hasegawa (2000) shows that mathematical knowledge cannot be transmitted by a teacher but is constructed by each student. In class discussions students’ conflicting opinions bring an enrichment of ideas and situations during which a particular concept can be constructed.

In (Gal & Linchevski, 2000), the ‘problematic learning situations’ (PLR) are situated where the teacher has their own difficulties with helping students overcome difficulties they encounter. Several examples of such situations are described and possible explanations are presented. It is shown that even if the teacher identifies the existence of a difficulty and uses appropriate didactical means for overcoming it, the student ‘co-operates’ and the situation appears to have been solved, exploring the problem deeper, the teacher finds that there is no understanding or only a partial understanding. The paper contains PLR where the teacher assumes that the student’s understanding is on a certain point A but in reality it is at another point A’. The teacher’s task then is to correctly identify the point A’ and help to a new understanding. The identification of the student’s understanding and exploration of their thinking processes is based on interactive co-operation between the student and the teacher/researcher.

Brown & Coles (2000) focus on how to support pupils in asking their own questions, within context of the mathematics classroom, creating new insights into the structure of relevant problems. The ideas are elaborated on the background of students’ ‘needing to use algebra’. Here the exploration of difference or sameness leads to extending pupils’ ideas by asking their own questions.

Steinbring (2000) has studied social discourse and a reflexive discussion, and shows by analysis of teaching episodes how individual
learning strategies and social-interactive constructions of knowledge favour different forms of an epistemological development of new mathematical knowledge. Construction of a new knowledge is not only an individual process, but collective processes make potential development of new knowledge possible.

2. Our research

When studying questions related to using constructivist approach to teaching (mathematics) we use variety of methods: longitudinal evaluation of teaching effectiveness by comparison of periodic testing of parallel classes, direct observation of the milieu of the classroom and analysis of teaching strategies, the teachers accounts of their own classroom experience, analysis of audio/video recordings of lessons and children’s written work. In the school year 2000-2001 we faced a singular opportunity. One of the authors of this paper taught mathematics in two parallel classes of the ninth grade (9.A and 9.E referred to below where students are age 14). In 9.A she has been teaching the class for five years and using constructivist teaching methods (the SC type class in (Kubínová, Mareš & Novotná, 2000)). She has never taught the other class (9.E) before. It is well known that previous teachers taught in an instrumental way.

In mid-September 2000, the input diagnosis of both classes was formed based on direct observation, the analysis of students’ written tests and interviews with students and with teachers who had taught there in the previous year.

INPUT DIAGNOSIS (15.9.2000) (Fig. 1, 2; b - boy, g - girl)

In the previous period

- the emphasis in the mathematics teaching was put on:

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<tr>
<td>Long-term concepts preparation</td>
<td>Transmission of ready-made knowledge</td>
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<td>Constructing concepts</td>
<td>Instructive teaching strategies</td>
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<td>Cultivation of communicative abilities including mother tongue development</td>
<td>Assigning and elaborating tasks mainly in the written form</td>
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<td>Work with diverse information sources in and out of school</td>
<td>Work with textbooks and mathematical tables as the only “legal” information sources</td>
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<tr>
<td>Long-term concepts building in the student’s cognitive structure</td>
<td>Immediate student’s performance</td>
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<tr>
<td>Work with an error as a source of cognition</td>
<td>Error as an indicator of the immediate student’s performance</td>
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<td>Evaluation of qualitative changes in the student’s work during a certain period</td>
<td>Evaluation of the immediate student’s performance when solving standard problems</td>
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<tr>
<td>Use of inter-disciplinary links and solving real life problems</td>
<td>Solving standard mathematical problems</td>
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<tr>
<td>Cooperation, team work and support of social links in and out of the class</td>
<td>Individual students’ work</td>
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- **the teacher was apperceived by students as:**

  **9.A**
  An authority providing enough space also for the ideas of students
  A person guiding the teaching/learning process
  A facilitator and advisor (also in matters not directly connected with mathematics teaching)

  **9.E**
  An authority who does not need to provide students with space for their ideas
  The only person who has the right to decide about the teaching/learning process
  A person whose duty is to transmit ready-made knowledge and instruct students what they are to do
SITUATION A (results of observations from the period September – mid-October 2000)

Teaching topic: Repetition of the topic, Operations with powers, Deriving of formulas for simplifying algebraic expressions

- **Students:**
  
  **9.A**
  Solve without difficulties standard problems related to operations with powers
  Participate in deriving formulas for simplifying algebraic expression
  In cooperation with the teacher deduce basic formulas in the geometric and algebraic interpretation

  Verify the validity of derived formulas in various information sources in and out of school

  **9.E**
  Solve without difficulties only those types of standard problems related to operations with powers having been reminded just before
  Refuse to participate in deriving formulas for simplifying algebraic expression
  Expect the teacher to transmit ready-made answers and instructions, refuse to cooperate in their deriving, take the geometric interpretation as redundant complications in the grasping process (“how we should learn this and for what we shall use it when making calculations”)
  Do not take as important to verify the validity of formulas. “It is valid because the teacher said so.”

- **Teacher:**
  
  **9.A**
  Together with students “discovers” formulas for simplifying algebraic expressions

  **9.E**
  Together with students “discovers” formulas for simplifying algebraic expressions but students take it as a redundant “protraction”
Communicates with students, communication is double-sided, the emphasis is put on the exact mathematical verbalisation (it concerns students of the last year of compulsory education with the potentials for further studying)

Communicates with students, but are “learning”. Students accept only very slowly the fact that it is a kind of dialogue in which they are allowed to enter. They keep expecting the teacher’s monologue which brings them immediate information sources

Is taken by students as a part of the cognitive process, the teacher’s and students’ space are not separated

Is taken by students as an authority remaining “above them”, in spite of the teacher’s effort, the teacher’s and students’ spaces are separated

SITUATION B (9.11.2000 – discussion about the results of the written test assigned in both classes on 7.11.2000)

- **Students:**

  **9.A**
  Discuss errors made by some of them

  Petr and Klára explain one of the problems solution to their schoolmates

  Honza K. and Lukáš show their solutions where they used another solution than their schoolmates

  Nikola and Klára try to persuade others that Honza’s and Lukáš’s solution is too lengthy

  **9.E**
  Do not want to discuss errors made by some of them, ask for communication of the test results and the peer correction

  Ivana and Marek explain after the teacher’s demand how they solved one of the problems from the test
A group of students asks the teacher to solve a problem all together

Ask the teacher to solve all remaining problems together

- **Teacher:**

9.A
Regulates the discussion about errors some of the students made in the test
Praises Petr and Klára for the way how they explained their solution of one of the problems to others
Shows the differences in Honza K.’s and Lukáš’s solution in comparison with the standard solving strategy, appreciates their originality and shows possible obstacles when using the same strategy in other situations

9.E
Tries to discuss the reasons of errors some of the students made in the test
Helps Ivana and Marek to explain how they solved one of the problems from the test
Shows why various solutions of the assigned problems are correct, includes among them those found by students from class 9.A

Praises Nikola, Klára and other students for their contributions to discussing Honza’s and Lukáš’s strategy

Praises every student who participated in the discussion. Highlights that she values any contribution, i.e. also such cases which were not correct because they are instructive for the others

With the help of students solves one of the problems on the blackboard and highlights again the errors having occurred in the solutions

Solves two problems together with students. Guides students to comment solutions
SITUATION C (29.11.2000 – group work – classification of algebraic expressions)

- **Students working groups:**

  **A**
  Are created by students themselves based on their decision.
  Search for criteria enabling to classify the set of 30 algebraic expressions.
  Discuss proposed criteria and finally, after the teacher’s agreement, classify expressions in groups of mutually equal expressions.
  Coordinate the group members work in order to forward the work.
  Present results of their work orally and in a written form and compare them with other group work results. Are not afraid of discussing their results with the others, accept the necessity to correct their solutions in case of having made an error.
  Finished the task in given time and presented their results on the notice board.

  **E**
  Are created after the teacher’s intervention, students learn this type of work very slowly.
  Ask the teacher to give them criteria for classifying assigned algebraic expressions.
  Are passive in the process of selecting criteria, therefore the teacher proposes to classify expressions into mutually equal expressions. Groups accept this alternative, Martina stresses that “… we have already done it”.
  Are perfunctory, in most cases students do not cooperate together.
  Did not manage to present their results, did not want to present even partial results being afraid that their classification is not correct.
  Did not finish the task in the given time, asked for an extra time to finish.
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<th>Teacher:</th>
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<td><strong>9.A</strong></td>
<td>Does not interfere in the working groups formation</td>
<td><strong>9.E</strong></td>
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<td></td>
<td>In a covert way regulates the appropriate criterion for a group of expressions classification</td>
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<td>For the time being does not comment the group work results in order not to influence the process of solving the task</td>
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<td>Summarises the discussions and praises the individual group work, proposes to present results on the notice board</td>
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<td>Encourages working groups to choose another criterion and elaborate the task again</td>
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(Kubinová & Novotná, 2002) focuses on the development of students’ understanding of mathematical concepts when the constructive teaching method SC for 4 years had been applied. The findings are illustrated by the topic Functions which is commonly agreed to be one of the difficult topics of school mathematics. The phenomena related to the creation and fixing of the function concept are studied.

3. Concluding remarks

Our research is in accordance with the following ideas from (De Corte, 2000): “… we should realise that powerful learning environments … require drastic changes in the role of the teacher. Instead of being the main, if not the only source of information – as is often still the case in average educational practice – the teacher becomes a ‘privileged’ member of the knowledge-building community, who creates an intellectually stimulating climate, models learning and problem-solving activities, asks provoking questions, provides support to learners through
coaching and guidance, and fosters students’ agency over and responsibility for their own learning.” From the evidence above it is clear that the teacher’s role is crucial, the teacher has to understand and respect the situation in each individual group of students, it is not possible to transmit the methods and forms of work which were successful with one group of students to another without any modifications, however it is possible to use experiences gained with one group of students to organise work in another group.

In (Edwards & Jones, 1999), the grouped categories of students’ views of learning mathematics in collaborative groups were classified. The following were clearly identifiable in our analysis of 9.A and 9.E performances in school mathematics: benefits of working together, respecting others in the group/sharing knowledge, confidence building and speed/volume of learning. In the class where the interactive teaching strategies were newly introduced (9.E) it influenced the climate in the class first, the influence on the mathematics behaviour and knowledge was significantly milder and occurred later. To change students’ gained norms of acting to a greater extent demands a long period of phased transition from transmissive teaching strategies to constructive ones (in our case, after 8 years of schooling, one school year was not sufficient).

In our experiment the role of peer interactions in the process of cognitive development was important. To profit from them needs a long experience of students in the similar activities, the enlargement of their self-confidence as well as the changes in their attitudes towards the subject. Students urgently need to see clearly mathematics as the subjects having narrow links to other subjects and mainly to the life situations.

References


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