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MATHEMATICS MADE POPULAR: A CHANCE FOR BOTH PUPILS AND TEACHERS

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Abstract. The contribution reports on an untraditional presentation of mathematical activities for elementary school pupils, which are being prepared as a part of grant focused on developing pupils' interest in mathematics and change of their attitude to mathematics as a school subject. Solving non-standard tasks, competitions, games and manipulative activities provide pupils, teachers and parents with a chance to change their perception of school mathematics.

1. Introduction

Motivation is seen as an important precondition of efficiency of mathematical education by didactics of mathematics. It is a key element in pedagogical practice as it assigns subjective sense to learning activities of pupils. Usually it is seen as a result of interactions between pupil's personality, teacher's personality, classmates and subject matter. The role of elements of motivation such as teaching tools, didactic games and non-standard tasks has been stressed in a number of recent works (for an overview with respect to educational reality see *Skalková, 2005*).

In the contribution I report on activities performed at elementary schools in the Olomouc region. When solving a *Playful mathematics* grant we performed a set of activities, which aimed at presenting mathematics in a way other than as a boring and uninteresting subject to pupils and their parents.

2. Motivation: a constructivist background

The issue of motivation in mathematics has become very important due to the comprehensive reform of the system of elementary school curricular documents. So far pupils have been required to acquire a prescribed content of

knowledge, information, activities and values. However, the new curriculum does not treat the specific prescribed content acquisition as a primary educational aim. It is rather a partial aim or a means of accomplishing a more general educational goal – the ability of every member of the society to make use of and apply specific results of his/her education in practical real-life situations. The importance of the educational content is not diminished – the focus of interest is rather shifted to something on a higher level. It is the pedagogical constructivism that is one of the most important trends following the requirements of the new educational paradigm. This wide range of attitudes attempts to adapt the means of education (especially methods and forms of teaching) to natural ways of pupils' learning.

Therefore, we assume that motivating pupils to be active is the primary task for the teacher. Once the teacher has been successful, the constructivist cognitive process of the pupils has been started – the pupils start creating their own images and building their own structure of pieces of knowledge. The pupils' internal world becomes a place where comprehension processes take place, images occur and concepts crystallize. This process of construction is influenced by previous knowledge, skills, experience and mental structures (cognitive maps) already acquired by the pupil.

This is based on respecting individual characteristics of the learners, i.e. especially their pre-concepts and individual experiences and learning styles. Implementing constructivist approaches is not trivial, as it requires conditions, which encourage and support pupils's activity. It is obviously the teacher – facilitator who is the cornerstone of the constructivist teaching. The teacher helps pupils to create new pieces of knowledge and prepares various sources of information for pupils' comprehension.

Mathematics for tomorrow's young children should become an environment for developing their personality. The idea of humanization, in which the school equals a service to children and a tool in their development, the center of which are affective components of learning (*Crowl et. al., 1997*), is of key importance in this respect. Developing the personality of a child is seen as education in the broadest sense of the word. Children are not objects of lecturing but subjects of their own learning. (*Wittman, 1997*) A teacher in school is to develop students' know-how, their ability to reason as well as to encourage their creative thinking. (*Polya, 1966*) This enables changing concepts, forms and methods of teaching mathematics so that the teachers could teach mathematics in a creative and interesting way and could become agents of a new and challenging class environment. At the same time, parents can learn at least part of what their children know – to see the constructivist oriented teaching mathematics based on intersubject integration (ópen classes"). They

can see the challenges and experience of their children, however, on condition that they come and share the experience with their children (*Kafoussi, 2006*).

3. *Playful Mathematics* project characteristics: problem, goals

The *National programme of research II* project of the Ministry of Education, Youth and Sports named *Research on new methods of creativity competitions for the youth focused on motivation in scientific area, especially in mathematics, physics and chemistry* is a chance to apply efficient instruments of motivation in teaching mathematics while following the basic constructivist principals. When solving one particular task of the project (preliminary name *Playful mathematics*, manager B. Novák) we were inspired by the abovementioned ideas and tried to confront them with the actual elementary school practice. Our experiment focused on creation and support of and research into educational efficiency of a number of activities: school mathematical competitions, projects, events for parents and public. The project is aimed at various elementary school target groups: mathematically talented pupils as well as ąverage"pupils (focus on raising and developing their interest in mathematics) or special needs pupils. The events are prepared in order to give pupils (even the less mathematically talented ones) a chance to acquire new mathematical experience and especially to let them get to know mathematics as something else than a boring subject – as an environment for personality development, interesting experimenting and discoveries. Reflection of the participants' view is very important in this respect – the participants are welcome to subsequently give their comments on both the content and the form of the event.

4. *Playful Mathematics* project characteristics: methods, ways of realization

A sociological research performed on a big sample of pupils (645 pupils aged 12, incl. 423 elementary school pupils, 222 pupils of 8 year grammar school, 276 boys, 369 girls) studied current interest of pupils in mathematics and natural sciences and their views of social status and applicability of these branches of science. The average grade (grading as in schools, 1 = the best, 5 = the worst) of mathematics was 2,04. Its popularity as a subject turned out to be quite good – 5th place out of 14 school subjects.

We aim at creating the basic framework of new competitions and other activities and advertising them. The activities include seminars on didactics for students and teachers, afternoon workshops on games, competitions, etc.

When applying and performing the activities we rely on co-operation of the researchers (a team of 8) with elementary school teachers taking part in the project. Tutoring students and PhD students is another important part of the project. Between November 2006 and May 2007, 12 events took place at 8 schools with more than 1000 pupils as participants. Such activities offer possibilities to:

pupils / students to be given space for interesting experiments and discoveries, activities connected with everyday experiences, projects,

teachers to change the approach, forms and methods, to be able to teach mathematics in an inspiring and interesting way, to help in creating the new climate, challenges for both them and the pupils,

parents to get to know part of what their children learn, find out that mathematics need not be boring and uninspiring formula training, however, they must come, see and share experience with their children.

The events are preceded by a systematic preparation of pupils during classes. The pupils are trained in tasks interpretation and presentation, arguing skills when defending one's way of solving the task, communication skills when co-operating on solving the task (pair work, group work, class work). This develops a number of competences: *competence to learn, citizen competence, work competence, competence to solve problems, communicative, social and personal competences.*

Mathematical activities performed in the project could be categorised as follows:

a) *games*, e.g.: sudoku, crosswords, board games, computer games, brain teasers

Didactic game require that the learning material is used in uncommon situations; otherwise the students won't be challenged to develop analytical and mathematic skills. Each game has to be prepared according to the principles of the theory of didactical games and must have special phases, which children have to go though in order to learn something new in mathematics. We believe that the most important feature of the game is that children acquire their knowledge without the didactical influence of the teacher as they work on their own. Researches report that regardless of the subject matter pupils working in small groups tend to learn more of what is taught and retain in longer than when the same content is presented in other instructional formats. This pedagogical sense of games could be characterized as follow (*Novák, 1995*):

- motivation of pupils, making them active,
- possible use of the game for making students work on their own, competitions (of individuals, groups etc.),
- development of counting skills.

Some examples of games include:

- *surprising assembling* – geometrical jigsaws or assembling solids without gluing, tantangram type or Columbus' egg type brain teasers
- *agic paper* – origami (water lilly in blossom, box, dog, etc.),
- *matches type brain teasers* (move the matches so that ...),
- *pyramid puzzles* – number pyramids, clusters and other number based tasks,
- *"funny"tasks* – aimed at logical thinking developement,
- *ęstimate the number of"type tasks* – e.g. of beads, beans or other small objects in closed jars, words on a book page or on a handwritten sheet of paper.

b) *activities connected to everyday life (projects)*

Some examples of such activities include:

- *Building a town* project, where pupils place themselves into a position of a citizen who wants to build a house. They have to consider financing (i.e. savings, loans, bank, jackpot, etc.), choosing the suitable plot (thus e.g. count the area), design, project, construction or buying the material (i.e. consider discounts, prices, etc.)
- *Treasure hunt* project, where pupils have to find the hidden treasure (such as sweets, small gift objects). The treasure can be found after solving a number of everyday life tasks including measuring, number and volume estimates (*How much / how many?* tasks), calculator calculations, navigating through the labyrinth, etc.

c) *unusual mathematical problems*, e.g.: *Kangaroo problems* (such as the following ones).

- On the left side of the Main Street one will find the housenumbers 1, 3, 5, ... , 19. On the right side the housenumbers are 2, 4, 6, ... , 14. How many houses are there on Main Street?
  a) 8 b) 16 **c) 17** d) 18 e) 33

- Four people can sit at a square table. For the school party the students put together 7 square tables in order to make one long rectangular table. How many people could sit at this long table?
  a) 14 **b) 16** c) 21 d) 24 e) 28

- Six weights (1g, 2g, 3g, 4g, 5g and 6g) were sorted into three boxes – two weights in every box. The weights in the first box weigh 9 grams together and those in the second box weigh 8 grams. What weights are in the third box?
  a) $3g$ **and** $1g$ b) $5g$ and $2g$ c) $6g$ and $1g$ d) $4g$ and $2g$ e) $4g$ and $3g$

- Four crows sit on the fence. Their names are Dana, Hana, Lena and Zdena. Dana sits exactly in the middle between Hana and Lena. The distance between Hana and Dana is the same as the distance between Lena and Zdena. Dana sits 4 meters from Zdena. How far does Hana sit from Zdena?
  a) $5m$ **b)** $6m$ c) $7m$ d) $8m$ e) $9m$

5. Our experience

Except for spontaneous reactions during and after the events a space is given to feedback from pupils, parents and teachers. A feedback questionnaire had been prepared, its evaluation will be performed before the project completion:

a) Evaluate the following statements (use the ++, +, 0, -, -- range):

[1] I enjoy mathematics.
[2] I like solving non-traditional mathematical tasks.
[3] I like solving brainteasers; I play chess or other board games.
[4] I like working with a computer.
[5] I found today's tasks simple.
[6] I solved the tasks successfully.
[7] What I was asked to do was new and unusual.
[8] I enjoyed being a part of a team and helping each other.
[9] On the whole, I liked the event.
[10] I would welcome another event like this one.

b) Choose and write the names of five activities, which you took part in, and sort them from the best one to the worst one:

c) Write your own assessment of the event.

At the same time, both children and their parents responded on a board titled "What I liked most / least". The following are sample reactions of parents: "We liked all activities because one has to think. Even if not successful, one has to think about the task.ór "I liked the smart children who prompted me when I was at a loss."

Most pupils enjoy their being both solvers and "first-aid staff", i.e. those who give and evaluate the tasks. Some sample reactions include:
Vojta: "I liked that there were so many customers at our post. The sweets almost disappeared!"
Vendulka: "I liked folding paper – I finally learned how to do things!"
Jana: "It was nice, it was superb!"
Mirek: "I liked it all! I hope there will be another event like this!"

During the events the teachers are also able to uncover some characteristics of their pupils or social relations in their classes. One of the teachers pointed out that: "Terezka is a rather quite, thoughtful and not so active a child. Yet when her parents were present, she was a leading personality of her post. Ondra, otherwise an average pupil, was most devoted. Jana seemed to be a good organiser, Radek, a rather introvert person, was very happy when he solved the task on his own – a quite adequate reaction on one's success. This is typical of Radek – he is very quiet in lessons; he does not speak even when at a loss – he tries to ignore his problems. When being approached, he reacts fearfully. However, he rewards even a partial success by a great joy and start of work. Yet he is not always able to continue on his own. This explains his joy after solving tasks, which were not problematic for other pupils. Lucka, quite weak in mathematics, could manage her post not only as an organiser but also as a 'professional' giving 'scientific' advice. Furthermore, she was able to show her readiness to help."

6. Conclusion

We tried to show at least some possibilities offered by the *National programme of research II* project at Faculty of Science and Faculty of Education, Palacký University in Olomouc. We aim at increasing motivation of pupils for mathematics, improving perception of mathematics as an interesting school subject and making pupils learn mathematics. Our ambitions include utilizing non-traditional forms as a suitable tool for making mathematics more popular, forming positive attitude of pupils to mathematics and improving

the overall class environment. Subsequent reflection and evaluation is important. We have learned that pupils as well as parents and general public like the events. We believe that this is caused by the fact that the events give everybody an unconventional view of mathematics, increased their interest in studying context and relations in problem solving. As far as motivation is concerned, this has enormous importance. We are happy to see pupils' interest and enthusiasm, especially that fair play rules were never broken. This gives us the feeling of having done a good and meaningful thing.

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