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Teaching
Mathematics and
Computer Science

Report on

Problem Solving in Mathematics Education

ProMath 6 Conference,
8–11 September, 2005, Debrecen, Hungary

Compiled by Tünde Kántor

Abstract. The sixth ProMath Conference was organized at the University of Debrecen (Hungary) in the year 2005. There were 12 presentations. After a short historical introduction we present the 12 abstracts written by the authors.

Key words and phrases: problem solving, new researches on teaching of problem solving, problem solving processes, mathematically talented pupils.

ZDM Subject Classification: C30, D50.

Problem solving has been one of the main directions of investigation in the international discussion on the teaching of mathematics.

The ProMath Group was founded in 1998 on the suggestion of Erkki Pehkonen (Finland) as a Finnish-German Group.

The ProMath Group wanted to promote the research about problem orientation in mathematics teaching and its practice in school. In July 1999 this Group met in Jena (Germany) on a conference about creativity. In September 2000 they organized a little meeting at the University of Bielefeld (Germany). In May 2001 they met in Turku (Finland), where a Greek Colleague joined them, so the ProMath Group became an international group. In September 2002 a meeting

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took place in Bielefeld. In 2003 a ProMath Conference was held in Jena with participants from Denmark, Finland, Germany, Greece and Hungary. In June/July 2004 a bigger conference was arranged in Lahti (Finland). This conference was before the ICME 10 (Copenhagen), so a lot of people could visit it. In September 2005 the sixth ProMath Conference took place at the University of Debrecen (Hungary).

Proceedings have been published for two meetings: Turku 2001, Jena 2003.

The next meeting is planned to take place in 2006 in Komárom (Slovakia).

Now we present the abstracts. The abstracts are neither proof-read by the compiler, nor their language is checked. Therefore every author is responsible for his/her own text.

Mathematics and Music

A Topic for Interdisciplinary Problem Fields

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Music offers a lot of opportunities for connections of mathematics and arts on secondary level. First of all rhythm and notations of classical music provide exercises for fractions (in grade six or seven) at which we also can deepen knowledge about music. The analysis of different chords and the sounds of instruments combined with creating super positions of sinus-functions then build a problem field for grade ten or eleven. Also the analysis of number-symbols and geometrical forms within the notation as well as symmetric patterns in given compositions or the discussion of structures of modern composition techniques are problem fields for connecting mathematics and music on higher secondary school level up to university level. The development of pitches and scales respectively tunes is another problem field in which the development musical theory from Pythagoras up to the twelve-tone- technique can be opened up by mathematics.

In my presentation I will schedule such problem fields concerning mathematics and music and go more into details with the problem field of the development of our heptagonal scale of tones in Pythagorean, diatonic and well-tempered tune.

Non-transitive structures, students' activities in a rich problem field

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Starting with the well known set of dices given by B. Efron, we asked for "improvement" i.e. for sets with higher chance to win for every point (which is build up by two dices) in such an "Efron-circle". In the "Hamburger Projekt zur Talentförderung" we try to simulate processes of theory-creation. This process integrates e.g. self-controlled asking and solving of various different problems, building of concepts and individual representations.

To learn more about the organisation of such settings we watched closely production-processes of certain non-transitive structures and genesis of proofs in our groups.

An everyday life problem related to expected values

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Today there is a change in Hungarian school-mathematics. Following the trends of PISA it has to pose much more weight on the real world problems. There is a challenge to bring in nearer the old famous Hungarian mathematics tradition and the provocations of the modern world. We consider the following problem:

"Suppose there was one of six prizes inside your favorite box of cereal. Perhaps it's a pen, a plastic movie character, or a picture card. How many boxes of cereal would you expect to have to buy, to get all six prizes?" First we build a model for this situation. After solving the problem on two different ways (one of them is known the second is suitable to answer other questions) we will generalize the problem in two directions: the number and the distribution of prizes.

Levels of teachers' listening in working with open problems

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Teachers' questions and pupils' responses form an essential part of a lesson in school. Especially in the use of open-ended problems, communication between the teacher and his pupils is in a key position. Mathematics is not about getting answers, but about developing pupils' insight into relationships and structures. While the role of communication in classroom cannot be overemphasized it has to be noticed that the level of teachers' listening matters. Here we will develop a hierarchic structure to classify teachers' listening.

Problem solving and problem posing revisited – some additional steps towards theory building and outlook on possible implementation

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Mathematical problem solving and posing are already taken for granted as guiding ideas in mathematics education (cf. Stacey 2004). Nevertheless, there are still deficiencies and difficulties in theoretical clarification as well as in implementation in normal classroom teaching.

We take the work of Schoenfeld 1985 and his latest suggestions (Schoenfeld 2005) as a starting point for some critical remarks and questions towards a more encompassing theory of mathematical problem solving and finding. We look for some possible relations to modern contributions to procedural and conceptual learning (Haapasalo & Kadijevich 2000), to questions of understanding (Fennema & Romberg 1999), to brain research (Spitzer 2002) and history of problem solving (Zimmermann 1991).

This framework gave us some additional possibilities for implementations.

Why is problem-solving difficult?

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This paper presents the role of mental operations in problem solving and ways to improve them through mathematics teaching.

Using two concrete examples we illustrate the possible difficulties and how to avoid them.

Anatomy of a contest problem

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In this article we will be concerned with the heuristics of solving a mathematical contest problem. We will discuss a problem of the XIV-th International Hungarian Mathematical Contest (Miskolc, Hungary, 2005). We are analyzing the written solutions of Problem 5 (grade 9) based on the works of the 59 contestants.

The main aims of our investigations were: to identify the applied solutions, the strategies, the misconceptions of the contestants and to draw some conclusions for the fostering of talented students.

Space perception abilities (and space geometrical problem solving) in a group of 3rd university teacher students

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In my PhD research I focus on teaching space geometry, and space geometry problem solving with combining of different tools (computer animation, traditional models, worksheets etc.). I work with third year university teacher students. In this article I would like to write about a pilot studies pretest, in it

about a space perception part of this test. With the help of this test I try to analyze the students' space perception abilities and space geometry problem solving skills, which are relevant to my work and with the help of this test I try to identify their level in these skills.

What does it mean to be sensitive for the complexity of (problem oriented) teaching?

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Teaching is complex. And often requested problem oriented mathematics instruction is even more complex than traditional instruction. From that special demands on the teacher and because of that on teacher education arise. At least teacher education at university should include attempts to sensitize becoming teachers for the complexity of (problem oriented) mathematics instruction first. For development and testing of new complementing elements of education, there has to be constructed a diagnostic instrument and to be elaborated more precisely, what is meant by sensitivity for complexity. First results will be given in this article.

Comparison and analysis of sequenced problems

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As I am trying to answer the question: How to create sequenced problems? I examine many of given problem sequences. I compare and classify the sequenced problems from different points of view like: the aim that they are created for, the change of the difficulty level within the sequence, how open the problems are, the used problem solving techniques, and at the end I formulate a few general requirements of the sequenced problems.

Problems in mathematical problem-solving

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Traditional mathematics education in Hungary follows the Pólya-model. Hungarian textbooks teach students using this method and professors of mathematics education analyse its applications. It is evident for us to use it to examine mistakes in problem-solving. Besides the concepts of Pólya, we use the ideas of a Hungarian psychologist in our paper. We try to connect these concepts in order to describe mistakes in mathematical problem-solving. Combining the two theories we can give guidance to Hungarian mathematics teachers that they can easily use in their everyday work. At the end of the article there is a short description of another application of this idea.

Three Main Ways to Improve the Instruction in Mathematics

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The demand for more elements of problem solving and higher-order thinking in mathematic instruction is widely discussed nowadays. This article suggests three main ways to improve the instruction in mathematics in secondary schools in order to meet these demands. The three ways are using questions and inductive reasoning, using special problem tasks and using investigations and modelling projects. Some examples from the author's collection of research data in a Finnish secondary school are used to elaborate the issue.

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