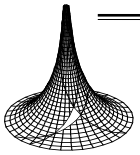

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Teaching
Mathematics and
Computer Science

Report of Meeting
Researches in Didactics of Mathematics and Computer Sciences
January 21 – January 23, 2010,
Debrecen, Hungary

Compiled by K. Lajkó, Gy. Maksa and Zs. Páles

Abstract. The meeting Researches in Didactics of Mathematics and Computer Sciences was held in Debrecen, Hungary from January 21 to January 23, 2010. The 42 Hungarian participants – including 16 PhD students – came from 5 countries, 14 cities and represented 25 institutions of higher education. The abstracts of the talks and the posters and also the list of participants are presented in this report.

Key words and phrases: new methods in teaching, experiments in teaching, talent care, history of mathematics and computer sciences.

ZDM Subject Classification: A60.

The meeting *Researches in Didactics of Mathematics and Computer Sciences 2010* was held in Debrecen, Hungary from January 21 to January 23, 2010 at the hall of the Kölcsey Ferenc Teacher Training College of the Reformed Church. It was organized by the PhD School of Mathematics and Computational Sciences of the University of Debrecen, the Kölcsey Ferenc Teacher Training College of the Reformed Church of Debrecen, and the Faculty of Informatics of the University of Debrecen.

The 42 Hungarian participants – including 16 PhD students – came from 5 countries, 14 cities and represented 25 institutions of higher education.

Professor Gyula Maksa opened the meeting and welcomed the participants to Debrecen. He emphasized that the aim of the meeting is to get acquainted

with each other's results on this field and to offer possibilities for PhD students to present their works and to know the opinion of the sophisticated colleagues about them.

The scientific talks and posters presented at the meeting focused on the following topics: on the didactics of mathematics itself, new methods in teaching, experiments in teaching and reports on the results, history of mathematics and computational sciences.

The social program – beside the common lunch and dinners – included a reception at the hall of the Kölcsey Ferenc Teacher Training College of the Reformed Church where vice-rector Professor József Daragó welcomed the participants on behalf of the Kölcsey Ferenc Teacher Training College of the Reformed Church of Debrecen. Next day the participants visited the famous Munkácsy's Trilogy in the Déri Museum Debrecen.

The closing address was given by Professor Zsolt Páles, the leader of the PhD School of Mathematics and Computational Sciences. He emphasized the importance of the meeting in the PhD training in this area. He thanked the organizers – especially Eszter Herendiné-Kónya, Margit Tarcsi, Piroska Bíró, the staff, the invited lecturers, and the chairs of sections for their efforts and contributions to the success of the meeting. Finally, he announced that the next meeting is planned to be organized in Satu Mare, Romania.

Abstracts of the talks and posters follow in alphabetical order and these are followed by the list of participants.

Abstracts of talks

Alternative methods used at the Kindergarten- and Primary-school Teacher Training College of Babes-Bolyai University in Satu Mare

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As senior lecturer of mathematics at the Satu Mare Kindergarten- and Primary-school Teacher Training College of Babeş-Bolyai University, I consider it to be important to let students become familiar with the alternative methods, especially with the method of co-operative learning. I let students become familiar with the main concepts of co-operative learning, as well as some co-operative

methods, during lectures and seminars through experiential learning. In the research presented in the thesis I tried to find out how effective students consider the learnt alternative methods to be, whether they think that those methods could be used during mathematics lessons/activities, as well as which are the parts of the lesson when those methods could be used most effectively.

Comparing contemporary Maths education in Hungary and in the UK

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Teaching Maths in today's England is significantly different from the Hungarian methods. To make it simple, we can say that the English method is more practical while the Hungarian way of teaching is based on a more exact approach. The aim of this presentation is to demonstrate these differences using examples from everyday teaching practice in England. We also discuss the question whether there are any aspects of the English way of teaching Maths that could be effectively applied in Hungarian classrooms in order to improve our Maths education.

"HT-System" - a New Approach to Illustrate Analysis

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As we had got a course of examination primes, we pointed out that primes, from which a certain operation brings complex structure elements onto existence, are atomic building stones. E.g., prime numbers, by multiplication, become composite ones in the circle of the natural numbers. Our aim is to rove an opposite road by the so called HT-system: From the complex structure elements out we try to exploit the concealing atomic building stones.

Word processing beyond MS Word

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I launched a survey to reveal the differences in word processing habits regarding the type of word processor, language and country. Considering the type of word processor the hegemony of MS Word is unquestionable. In earlier surveys it was found that most of the users of MS Word apply incorrect solutions to complete their tasks. The question was whether users of other type of word processor commit the same mistakes or not, whether these incorrect solutions are language or country independent. This novel survey revealed that there is no difference between the users considering the mistakes they commit. This result indicates that the mistakes are software independent; therefore, it is the theoretical background of word processing that is missing. Teaching word processing should thus be more than teaching the features of software, a firm theoretical background of basic word processing skills should also be taught. Moreover, it was also found during the survey that some of the teachers of Informatics and authors of books on word processing also have serious problems with these basic rules. In my opinion, first the teachers should be taught these rules, and then they should teach their students the correct method to create a properly formatted text.

The catching up of mathematical knowledge with a computer programme in higher education

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The mathematical knowledge of most of the students admitted to higher education is far from the expectation; therefore the learning of new material becomes difficult. This problem can be related to almost all educational institutions. As a solution, students have to accomplish a catching up course but, unfortunately, the efficiency of the course doesn't live up to expectations. The objective of the didactics method is to develop a computer programme which helps students to study Mathematics on their own.

The formation of geometrical terms

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The Van Hiele theory was created by two Dutch researchers in the 1950s. The aim of this theory is to describe a student's level of geometric thinking. It has been widely used and has yielded important results. A few decades later a group led by the American researcher Usishkin developed a test whose aim is to determine the Van Hiele levels of pupils. They had several thousand American high school students take the test. Even today, the result of their thorough investigation is available to anyone who is interested. In 2009 I had several groups of Swedish student teachers as well as a smaller group consisting mainly of maths teachers take this test. I also had the opportunity to study the results of Hungarian student teachers. Most of the Swedish student teachers whose major is not maths are on the first van Hiele level, although you can find a few students who are on higher levels. Among the Swedish maths teachers no less than three are on the highest Van Hiele level. The first table containing the results of the Hungarian student teachers shows that far more of them are on the first, second and third Van Hiele level. The analysis of the received data is still in progress. In 2010 two additional groups of Swedish student teachers will be tested, and taking the results into account new geometry teaching material will be composed and tried out.

Research on performance of Hungarian primary and secondary school students in solving insight problems

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The main purpose of this presentation is to introduce the results of an empirical research which was conducted at Primary and Secondary schools in Hungary. The foremost aim of this research was to examine students' written performance in solving insight problems. Insight problems are non-routine problems, which solution requires changing the representation of the problem. The problems used in the research were collected from the literature according to Weisberg's taxonomy of insight problems. We will present the quantitative analysis of four insight problems used in the study. We will provide examples of the most frequently

occurring answers as well as examining the differences in performance of same age boys and girls.

Motivation in mathematics education

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We show some motivational examples, in which we use research and heuristic strategy. The aim of motivation is to strength the pupils´ interest and the work atmosphere in the class. The pupils solve interest problems, tasks and conundrums. We show some motivational tools and the place of motivation in the process of gaining knowledge.

Pictures from the History of Mathematics

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Professor Judita Cofman was invited scientific researcher in didactics of Mathematics in the Department of Mathematics at the University of Debrecen in the year 2001. Her task would have been to organize and lead the Ph.D. Program of Mathematics Didactics. She would have been the chief editor of the new founded mathematics and informatics didactical Journal Teaching Mathematics and Computer Science. She was only for a short time our colleague in consequence of her unexpected sudden death. Also nowadays we often ask us what would be her opinion, what would be her advice to us on solving some problems. Besides her mathematical didactical and historical works (What to solve, Numbers and Shapes Revisited, Einblicke in die Geschichte der Mathematik I-II.) we discovered her mathematical results in finite affine and projective geometry, for example the so called Cofman's theorem too. In this lecture we present the life and career of Judita Cofman, her mathematical and didactical works and we deal with her inheritance.

A comparison of informatics skills by genders of Hungarian grammar school students

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An analysis of informatics skills by gender in secondary grammar schools was made with the help of a web based Informatics Test. In accordance with widespread opinions the hypothesis was that boys would better than girls. After the evaluation of the test results the correctness of this presumption has emerged. First the Kolmogorov-Smirnov-test was used to see if the groups showed standard normal distribution in answering the questions. The means of the correct answers by gender were examined using a Z-test with two parameters and the deviation quotient was to calculate revealing how much gender influences the difference of means. Significance level was 5% through the analysis. Significant divergence by gender was found regarding theoretical knowledge and programming showing the hypothesis correct in this two area.

Why and for what are Excel and GeoGebra used in teaching calculus?

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Traditionally at our university, we start courses in Mathematics with Calculus in the first semester. Our experience is that acquiring the elements of this subject presents difficulties to students. According to Bruner's theory, the flexibility of the transition between the different levels of representation develops creative thinking. Among others, this is one of the reasons why we use computer methods for illustration and to give a deeper insight into the subject. Our first task was to find such programs which are available for everyone and do not need any particular grounding. The second task was to offer the students a possibility through which we can teach them the methods of learning. That is why we announced an optional course, in which we make up for the deficiencies and show the connections between the old and newer knowledge, on the grounds of the cognitive system of objectives of mathematics-teaching worked out by Tamás Varga and Zech. Besides the traditional paper-pencil method used in Calculus, we also teach graph-plotting with the help of Excel to support the level of material

activities, while with GeoGebra we strengthen the concepts learned in Calculus and their applications by bringing the symbolic level in front. By using computers, the iconic level is always present during the process of teaching-learning. The elements of this work are shown in my presentation.

Teaching of problem-solving strategies in mathematics in secondary schools

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Hungarian training of students with outstanding abilities is famous all over the world, less attention is paid to students with average capabilities. How could we help them? One way of this are the catch up programmes, where the students would have the opportunity to get to know and apply the different problem solving methods consciously. The question is: how much does explicit teaching of problem solving methods contribute to the development of problem solving abilities of the students.

In my hypothesis I assume that problem solving strategies are teachable, and explicit teaching of them increases the students' problem solving abilities significantly. On this purpose I initiated a series of experiments, during which I taught the forward- and backward methods within the framework of a developing course. After that I examined whether conscious application of these techniques would bring a positive change in measurable results, and besides, whether aptitude to problem solving thinking could be moved to a positive direction. Participants of the developing experiment were students from a secondary school (11th grade). In my presentation I sum up my methodology -like experiments, teaching trials, research work and my conclusions deriving from them, which I obtained in connection with the teachability of the two problem solving strategies. Applied research methods: monitoring the students, developing teaching experiment, pretest, post-test, analysis of the written works (documents) of the students, talks with the students, surveying the students, reviews and disputes of the students' problem solving.

Using GeoGebra in Teaching Functions

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Beside the applications in Geometry, the dynamical interactivity of the two windows, the Geometry and Algebra windows of GeoGebra makes it extremely suitable for the applications in representing functions. One can easily construct the file to visualize the point wise correspondence between the points of the domain and co domain of the function, to study compound functions. Using the animation, a function which is built in the slider - an extremely useful function of the software - one can study the transforms of the elementary function, the role of each parameter separately, and even their compound action. Special functions (see the respective section in the MacTutor History of Mathematics at http://www-history.mcs.st-and.ac.uk/) can be studied and represented in a suitable form, especially the so called "technical curves", those used in engineering, altogether with their associated curves (evolute, involute, inverse, pedal curve etc.) As a special example it was revisited the cubic parabola, and its symmetry, a curve used to approximate the chlotoid. It was compared the power of GeoGebra and Maple in analyzing the pair of compound functions $\sin(\arcsin(x))$, and $\arcsin(\sin(x))$ too.

Parametric and polar coordinate functions - besides using the built-in commands - can be easily obtained as the trace of the point moving along the curve. This is maybe closer to the technical properties of these curves, than the classical way of representing them.

Problems that lead to functional equations

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The solution of functional equations is one of the oldest topics of mathematics. D'Alembert, Euler, Gauss, Cauchy, Abel, Weierstrass, Darboux, and Hilbert are among the great mathematicians who have dealt with functional equations and methods of solving them. The firs expository monograph on the subject was written by János Aczél in 1961. This was followed by many others, some of them are due to hungarian authors. In the talk, we present some problems (not only

within mathematics) to which functional equations can be applied, and, in some cases, we sketch the solutions, as well.

The sum of the first n natural numbers of the same power and Bernoulli numbers

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In my presentation I demonstrate a new method to find the sum of the first n natural numbers of the same power. We can calculate these sums with the help of determinants and Cramer's Rule using a system of linear equations. In a similar way we can find a relationship by means of which we can also calculate the so-called Bernoulli numbers. This method can even be introduced and discussed in secondary schools - in special mathematics classes - according to the level and knowledge of the students.

The impact of social disadvantage on mathematics learning, problems and solutions

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In the mathematics classroom the social disadvantage appears as language difficulty, but it is hidden for the teachers. In our empirical study we gave refutation of teachers' belief that students from low social class are unmotivated (Kuhl test on motivation system). We used hands-o activity as a tool of problem solving. Hands-on activity, visualization, manipulation and other terms are speaking about Bruner's enactive mod of learning. These kinds of learning traditionally are used instead of problem solving, before, after or in the break of problem solving. In my presentation I show some results of our experiments.

Technical mathematics

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In recent years many traditional course books were written in mathematics at the Faculty of Engineering, University of Debrecen. The above books follow the usual curriculum in mathematics. On the basis of their experience in engineering education, the authors made a decision: some important applications from mechanics, physics, and economics need to be built into the curriculum of mathematics.

The course book entitled "Mathematical Tools in Engineering Applications" has been written for the lectures and seminars of the subject Mathematics I, which is in the syllabus of the Faculty of Engineering. The topics in the book follow the usual thematic of the subject, but the aim are not the teaching of mathematical concepts and tools, but the demonstration of their application in different engineering and economic fields, where the students will meet them.

The exercises are based on real technical problems. For example the objects in geometrical problems are parts of buildings, or components of machines. We hope the course book will help students to be able to apply mathematical tools in different engineering fields more effectively.

An algebra-didactic concept with a significant historical background in mathematics

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The subject of this study is connected to one particular field of mathematics at school. It reflects a complex aspect which is different from both common and revolutionary ideas of mathematics at school. It involves mathematical, didactic and historical elements. We do not take it for granted that by following previous ages' historical development, didactic profit can be reached today. However, we still find it valuable to study it in different fields of mathematics. This study concentrates on algebraic equations.

How can blind pupils see function graphs?

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The concept of function is of fundamental importance in the learning of mathematics. Graphs and visualizations are often used to analyze relationships between numerical data, but the current method of accessing them is highly visually mediated.

Last year we wanted to enable seven early blind pupils (age 13-14) to develop the ability to change their mode of representations of functions. These representations were: formulae, verbal descriptions, tactile graphs, coordinate planes adapted for the blind, 3D columns of varying heights and sounds (nonspeech audio to convey information).

Our method helps visually impaired pupils break down the structure of a mathematical problem, and this can lay the foundation for its solution. In addition, it also simplifies complex situations and makes abstract concepts more concrete, and thus more familiar. Furthermore, once the structure of problem is understood the ability of visually impaired pupils to read tactile graphs improves. Morever, using our method communication between teachers and pupils is strengthened by means of hand gestures.

Methodology in Higher Education (Teaching Mathematics to lower primary school teachers)

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Is there any didactics, or should there be, in higher education? I think the answer is yes. Just remember that in Bologna-type higher education often PhD trainees teach university or college students without any training in pedagogy. They do that mostly relying on their previous experience of the way were taught by former teachers. Depending on the measure of their innate "feeling for didactics" they can be more or less successful - more often less. Their students cannot understand their explanations, if they offer any at all. They tend not to think over problems, but, at the same time demand too much from their students. As they themselves can understand the 'material' they lack empathy to see

may cause difficulty for their students. They are unskilled in applying interactive methods or asking problem-oriented questions. Furthermore, there are lectures with many years' experience, still giving dull monotonous classes or filling in class time mostly with their students' oral presentations. These days, when fifty per cent of those who passed their final exams go on to higher education. When more and more exchange in life-long learning or distance education, it is increasingly important to apply good teaching methods in higher education, too. Moreover, differentiations of methods are to be used at a university of arts, sciences, engineering or economics. Teacher training surely deserves special attention in this respect as teaching successive generations will be the very profession of these students. From the sphere of teacher training the teaching of mathematics will be analysed in the following.

The examination of teacher training college students' geometrical concepts

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The topic of my doctoral dissertation is about the development of the concepts of square, rectangle, parallel, perpendicular and symmetry in lower primary. We have dealt with the improvement of the above-mentioned concepts within the framework of a teaching experiment in grade four. The follow-up test of the experiment had been taken by teacher training college students as well. The results will be described in the presentation.

Development of competency with the ActiveMath web-based interactive program

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In this presentation we show the internet-based ActiveMath program system for interactive learning and teaching of mathematics; we look at the possible roles of the system in the teaching process. We examine, by means of comparative analysis, on the one hand, of the LeAM Calculus course from the program and,

on the other hand, the business mathematics teaching plan of the business studies branch of basic training, whether the program system is suitable in support of the teaching of business mathematics as a subject at Technical High School level. By means of examples we show numerous definite applications for the development of competency.

Counting rectangular islands in a computer-supported learning lab

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Let a rectangular grid of size $m \times n$ be given. A height is assigned to each cell of the grid. We call a rectangular shaped part of the grid an island, if all of its cells are higher than its neighbouring cells. By fixed gridsize and neighbourhood-relation there exist optimal island-configurations, i.e., distribution of heights where the number of islands is maximal. We aim to explore those configurations. The question about the maximum number of rectangular islands was first answered by Gábor Czédli. He used lattice theoretic results. Similar questions about nonrectangular islands form the subject of recent mathematical research. In this presentation we attack the basic problem with elementary methods. For the representations of configurations and the characterization of the maximum a computer-supported approach was demonstrated.

Empircal researches

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This talk is about the applications of statistical tools in mathematical didactics.

Abstracts of posters

The formation of geometrical terms

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A very short presentation of the Van Hiele theory from the end of the 1950s.

A very short presentation of Usishkin's test from 1982.

My modifications to the scoring of the test.

My own test results: four groups of Swedish students did the test. Two groups were not majoring in math, one group was majoring in math and one group consisted mostly of the maths teachers of the student groups.

Additionally: half of a Yoshimoto-cube made of paper, a beginner's geometry test with the answers of a Hungarian student teacher, and the Van Hiele test with the answers of yet another Hungarian student teacher.

The power of double representation of GeoGebra

Pellumb Kllogjer
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In present we witness the high-speed progress of computer-based education, which allows educators and students to use educational programming language and e-tutors to teach and learn, to interact with one another and share together the results of their work. The mathematical programmes, teaching and learning software are probably one of the most important tools the computer-based education is based on. Beside many mathematical programmes, one which is used by a daily increasing number of users throughout the world is GeoGebra (published by Markus Hohenwater, 2004) explicitly linking geometry and algebra. The software affords a bidirectional combination of geometry and algebra that differs from earlier ones. The bidirectional combination means that, for instance, by typing in an equation in the algebra window, the graph of the equation will be shown in the dynamic and graphic window. This programme is preferred so much, probably because of its three main features: the double representation of the mathematical object (geometric and algebraic), no strong requirements as to the age and the pre-knowledge in using it (the students of the elementary school can use it

as well) and it is offered free of charge (simply by downloading it). In this paper we concentrate on the double representation of the mathematical object and its advantages in explaining and forming mathematical concepts and performing operations.

Teaching of problem-solving strategies in mathematics in secondary schools

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This poster is presenting the summary of a series of experiments carried out with 11- grade students from József Attila Secondary School in Monor. The question of the research was how the explicit teaching of the problem solving strategies increases the students' problem solving abilities. In order to get the answer to this question, I initiated a developing course with these students.

The poster is presenting the documents related to students' works and the test results after the developing course. It also contains opinions of the pupils' in regards with the developing course and with the learning of problem solving strategies.

Studying the level of cognition of the concept of area

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This study deals with the measuring of area, the introduction to the standard and non-standard units of area and the exploration of problems and deficiencies in the calculation of the area of various polygons. It also examines the level of knowledge of the standard and non-standard units of area acquired by pupils of various grades and the application of area computation in everyday life. We demonstrate a few particular solutions in which learners' hazy knowledge is revealed. We have also studied old Hungarian units of area which seem to be relevant in everyday life. For this reason we intend to fit these old units into the proposed developmental program for the students of the teacher training college.

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