

## TSG46 Agenda

### TSG46: Mathematical competitions and other challenging activities

Class: \_\_B\_\_ (Class A for TSGs with odd numbers; Class B for TSGs with even numbers)

#### Session 1 19:30-21:00 Beijing time, July 13<sup>th</sup>

Coordinator of the session: Boris Koichu

0. Time: 19:30-19:45

Title: Welcome!

Moderator: **Boris Koichu**, Weizmann Institute of Science

A short overview of the history of TSG46 and introductions of the participants.

1. Time: 19:45-20:30 (long oral)

Title: What competitions can tell us about theories in mathematics education

Presenter: **Maria Falk de Losada**

Institution: Universidad Antonio Nariño, Bogotá, Colombia

Abstract: This paper seeks to contribute to answering the question “What are the relationships between engaging students in challenging activities and fostering their creativity and mathematical habits of mind?” put forth by the organizers of TSG 46. It looks at the working interpretations of Raymond Duval’s theory concerning semiotic registers that are used by math educators and educational authorities, especially in Latin America, and analyzes the gaps and pitfalls that become apparent in the appreciation of mathematics as a language based on the dual purposes of seeking mathematical understanding and developing mathematical thinking, and seeks to provide both explanation and illustration in reference to the results of challenging activities.

2. Time: 20:30-20:45 (SO)

Title: How to identify multiple solution tasks for mathematical competitions

Authors/Presenter: **Ingrid Semanišínová**, Ľubomír Antoni, Stanislav Krajčí, Daniela Víťazková

Institution: Pavol Jozef Šafárik University in Košice, Slovakia

Abstract: In order to motivate more students for participation in mathematical competitions it is important to choose tasks which enable several solutions which vary in difficulty and used concepts and properties. Such tasks are less dependent on particular concepts, properties or methods of solutions. In the paper we illustrate the application of Formal concept analysis as a research tool for an evaluation of selected mathematical tasks. Based on students’ solutions we analysed two tasks from Slovak correspondence mathematical competitions with the emphasis on multifarious solutions. Data analysis showed that although expert solution space is wide enough for both tasks, the collective solution space for the task 2 is not sufficiently various.

3. Time: 20:45-21:00 (SO)

Title: Challenging math tasks for teaching through problem solving approach

Presenter: **Hoyun Cho**

Institution: Capital University, Columbus, Ohio, USA

Abstract: This paper summarizes a research-based practice on using challenging math tasks to teach mathematics through problem solving. It reviews the effectiveness of teaching mathematics through problem solving and how to define challenging math tasks. It also includes the importance of problem solving in developing mathematical habits of mind. Such habits include guessing, predicting, questioning, looking back, looking for patterns, analyzing a special case, modeling and representing a problem in various ways. The paper concludes with the story of one urban school that uses challenging tasks to teach problem solving skill, impact student enjoyment and attitudes, and develop a positive school culture regarding mathematics.

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**Session 2: 21:30-23:00 Beijing time, July 16<sup>th</sup>**

Coordinator of the session: Ingrid Semanišínová

1. Time: 21:30-22:15 (keynote)

Title: Unravelling the construct of mathematical challenge based on conceptual characteristics of mathematical tasks

Presenter: **Roza Leikin**

Institution: University of Haifa, Israel

Abstract: Mathematical challenge is central for learning and teaching mathematics. I define mathematical challenge as a mathematical difficulty that a person is able and willing to overcome. The construct of challenge is rooted in Vygotsky's notion of zone of proximal development and is associated with cognitive load theory. The former distinguishes between intrinsic cognitive load, which is linked to the cognitive resources a person must activate in order to satisfy task demands, and germane cognitive load which is linked to the cognitive resources needed for learning of new schema). Moreover, mathematical challenge is a function of the suitability of the task to students' mathematical potential, including its cognitive and affective components. That is, a task is challenging only when it embeds difficulty that is approachable for a person and that the person is motivated to overcome. I suggest that, mathematical challenge embedded in the task is a complex function of conceptual characteristics of mathematical tasks; didactical settings, including the use of technological tools; classroom socio-mathematical norms and a student's mathematical potential. In my presentation I will focus on conceptual characteristics of the task including the conceptual density of a mathematical problem to be solved, the task's openness, and the complexity of mathematical concepts, mathematical connections and logical relationships required for solving the problem.

2. Time: 22:15-22:30 (SO)

Title: A challenge of deciding who is right and why

Authors/Presenter: **Reut Parasha**, Boris Koichu, Michal Tabach

Institution: Weizmann Institute of Science, Israel

Abstract: The study focuses on a dialogical challenge, that is, a mathematical challenge associated with collective argumentative activity towards deciding which of (sometimes seemingly) contradictory solutions to a problem is right and why. A dialogical challenge is two-dimensional: the first dimension is related to understanding and validating the solutions, and the second one – to inventing an argument that would be convincing to the peer students. Three dialogical tasks, which have been tested in a classroom, are discussed. Based on the

examples, we argue that re-designing standard textbook problems as dialogical challenges provides valuable learning opportunities for high school students.

3. Time: 22:30-22:45 (SO)

Title: Students' expected gains from a modeling competition

Authors/Presenter: **Elisabeth Roan**, Jenifer Czocher

Abstract: This study is a post-hoc analysis of pre- and post- survey data from two rounds of a mathematical modeling competition comprised of high school and undergraduate students (n=107). The purpose of this study is to describe the expectations students held going into the competition and how those expectations compare to those held by researchers and designers of modeling competitions. Additionally, this study examines students' satisfaction with the competition in terms of their anticipated gains. Results show that students, researchers, and designers held differing expectations. We explore implications of this finding for broadening participation.

4. Time: 22:45-23:00 (SO)

Title: Math trails: Opportunities to learn rich mathematics outside the classroom

Presenter: **Rosa Antonia Thomas Ferreira**

Institution: University of Porto & CMUP, Portugal

Abstract: In this study, I analyze the reactions to an innovative and challenging activity conducted with a class of 22 Portuguese sixth graders, in a learning outside the classroom environment: a math trail. The students completed the foot trail in groups of five to six elements, supervised by their math teacher and some voluntary parents, including myself. The trail's tasks spanned an array of math curricular topics and were basically constituted by mathematical problems, that is, closed tasks for which the solving process was left open. In my analysis, I look at the three dimensions of the idea of active learning, namely students' intellectual, social, and physical engagement with the math trail, as well as students' affective responses to the whole experience. All three dimensions of active learning were visible in students' activity along the math trail, but the social engagement dimension stood out, as teamwork was always visible and a key element to solve (especially) the (most cognitively demanding) tasks. Students reacted positively to the math trail, showing enthusiasm and perseverance in completing the trail, as well as flexibility regarding the choice of strategies and the coping with difficulties, and being challenged to "see" mathematics in many aspects of their city, establishing connections of diverse nature.

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**Session 3: Session 3: 14:30-16:30 Beijing time, July 17<sup>th</sup>**

**Coordinator of the session:** Yi-Jun Yao

1. Time: 14:30-15:15 (keynote)

Title: Cutting a polygon: From mathematics competition problems to mathematical discovery

Presenter: **Kiril Bankov**

Institution: University of Sofia and Bulgarian Academy of Sciences

Abstract: The problems are the intellectual product of mathematics competitions. Many of these problems lead to interesting generalizations. Often the generalizations are beyond the elementary mathematics and they are real challenges for professional mathematicians. Such generalizations are a base of some of the discoveries in mathematics. This paper presents the

development of ideas, inspired by problems from mathematics competitions, as beautiful mathematical discoveries. The problems consider the partitions of a polygon (mainly a rectangle) into different shapes. Cutting a given polygon into finite number of certain shapes is a topic that offers a variety of tasks for mathematics competitions and raises questions whose answers are not yet known. Therefore, the topic is fruitful for both creation of problems for mathematics competitions and for mathematical discoveries. Starting from the fact that a square can be partitioned into a finite number of squares of different sizes, the paper poses the question of whether a square can be cut into a finite number of non-congruent isosceles right angled triangles. In connection with this, the known result that a square cannot be cut into finite number of right angled triangles all of whose angles, when measured in degrees, are even integers, is discussed. The paper presents also the story of the discovery that a square cannot be cut into odd number of triangles having the same area. Finally, the idea of tiling of rectangles is presented. At the end of the paper the fact that a rectangle can be tiled with finitely many squares if and only if the ratio of its sides is a rational number is discussed.

2. Time: 15:15-15:30 (SO)

Title: An introduction of Shanghai grade 11 mathematics competition

Authors/Presenters: **Yijie He** and Tianqi Lin

Institution: East China Normal University and Shanghai Key Laboratory of Pure Mathematics and Mathematical Practice, Republic of China

Abstract: Shanghai Grade 11 Mathematics Competition is established in 2002, for the goal “to promote digital mathematics activities, to stimulate students’ interest in mathematics and develop their ability of self-learning, exploration and practical application”. This competition allows and encourages the usage of various types of calculators (graphic calculators particularly recommended), with some problems specifically designed for that purpose. The competition problems are usually selected from the individual contributions of a group of experts and refined under thorough discussion, with the consideration of the mathematics curriculum requirements in Shanghai, the problem difficulty, and the various functions of calculator use. By analyzing the competition data in 2019, it is found that the competition was relatively difficult for most participants, while some top students shew their outstanding talents. The performance on some of the calculator-active problems was lower than the expectation of test designers. In view of the experience of teachers and students involved, this competition was largely successful and basically achieved the expectation of its founders and organizers. Preparing for this competition makes the participants experience the power of calculators and improves their ability to use technology. Advanced and diversified use of calculator is suggested to be further valued.

3. 15:30-15:45 (SO)

Title: POSA weekend-camps: A challenging mathematical environment for the highly gifted in Hungary

Presenter: **Eszter Bora**

Institution: Eötvös Loránd University, Budapest, Hungary

Abstract: Hungary has a rich tradition of nurturing mathematical talents: from different competitions to mathematical journals. In this paper a special weekend program based on discovery learning for the highly gifted will be presented. The purpose of the paper is to explore the successful components of the camps. These camps have been running since 1988 by Lajos Posa, during these years at least 350 camps for more than 1500 students has been organized, additionally in the last two and half decades most of the members from the IMO

(International Mathematical Olympiad) and MEMO (Middle European Mathematical Olympiad) teams were a student of Posa (Juhász & Katona, 2019). One of the special aspects of the program is the curriculum. The span of the curriculum is 5-6 years long designed for students from grade 6 to grade 11. It is structured around different problem-solving ideas or mathematical topics, thus forming various threads which are often intertwined, in that way the threads are forming a rich network of problems. An example of such a thread is described to demonstrate some of the aspects of the program.

4. Time: 15:45-16:00 (Poster)

Title: Competitions promoting the mathematical science

Authors/Presenter: **Valorie Lynn Zonnefeld**, Ryan Glenn Zonnefeld

Institution: Dordt University, Iowa, USA

Abstract: Competitions provide many benefits to students and the mathematics community at large while giving students exposure to important mathematical ideas and practices. This poster shares examples of successfully implemented competitions including relay races, March Madness Competitions, Fantasy Football, and "The Amazing Race". Some competitions have a specific mathematical focus: March Madness focuses on data analytics; Fantasy Football focuses on fractions, integers, or decimals; Desmos Designs focuses on functions. Other competitions include mathematics from across the curriculum as well as recreational mathematics.

5. Time: 16:00-16:30 (Summarizing discussion)

Moderators: Boris Koichu and Sergei Dorichenko

Content: Whole-group discussion of where we are in relation to the questions posed in the call for papers of TSG46, and with an eye on the future plans.

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## Overview

### Session 1 (Monday July 13 19:30-21:00 90 min)

Coordinator of the session: Boris Koichu

| Time        | Activity  | Presenters  | Title   |
|-------------|-----------|---|---|
| 19:30-19:45 | Welcome   | Boris Koichu  | Welcome, history of TSG46 and introductions                           |
| 19:45-20:30 | Long oral | Maria Falk de Losada  | What competitions can tell us about theories in mathematics education |
| 20:30-20:45 | SO        | Ingrid Semanišínová,<br>Lubomír Antoni,<br>Stanislav Krajčí,<br>Daniela Vířazková | How to identify multiple solution tasks for mathematical competitions |
| 20:45-21:00 | SO        | Hoyun Cho   | Challenging math tasks for teaching through problem solving approach  |

**Session 2 (Thursday July 16 21:30-23:00 90 min)**

Coordinator of the session: Ingrid Semanišínová

| Time        | Activity | Presenters                                | Title   |
|-------------|----------|---|---|
| 21:30-22:15 | Keynote  | Roza Leikin                               | Unravelling the construct of mathematical challenge based on conceptual characteristics of mathematical tasks |
| 22:15-22:30 | SO       | Reut Parasha, Boris Koichu, Michal Tabach | A challenge of deciding who is right and why  |
| 22:30-22:45 | SO       | Elisabeth Roan, Jenifer Czocher           | Students' expected gains from a modeling competition  |
| 22:45-23:00 | SO       | Rosa Antonia Thomas Ferreira              | Math trails: Opportunities to learn rich mathematics outside the classroom                                    |

**Session 3 (Friday July 17 14:30-16:30 120 min)**

Coordinator of the session: Yi-Jun Yao

| Time        | Activity               | Presenters                                   | Title   |
|-------------|------------------------|--|---|
| 14:30-15:15 | Keynote                | Kiril Bankov                                 | Cutting a polygon: From mathematics competition problems to mathematical discovery            |
| 15:15-15:30 | SO                     | Yijie He and Tianqi Lin                      | An introduction of Shanghai grade 11 mathematics competition                                  |
| 15:30-15:45 | SO                     | Eszter Bora                                  | POSA weekend-camps: A challenging mathematical environment for the highly gifted in Hungary   |
| 15:45-16:00 | Poster                 | Valorie Lynn Zonnefeld, Ryan Glenn Zonnefeld | Competitions promoting the mathematical science   |
| 16:00-16:30 | Summarizing discussion | Boris Koichu and Sergei Dorichenko           | Discussion around questions posed in the group proposal, and with an eye on the future plans. |