Mathematical Competitions for University Students: Experience of Moscow Institute of Physics and Technology

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In this paper I will give an overview of mathematical Olympiads (academic competitions) for university students based on my experience at Moscow Institute of Physics and Technology (MIPT). This overview will consist of two parts. I will start with explaining the notion of a mathematical Olympiad and naming usual pros and cons for the concept of a mathematical Olympiad for university students in general. Then I am going to give particular details about the experience of MIPT and different mathematical Olympiads at MIPT and abroad.

I will not distinguish between the terms "Olympiad" and "competition". By an Olympiad I mean a written test consisting of mathematical problems, resulting in sorting the students by their accomplishments and awarding them certificates, medals or prizes. It differs from other tests held at universities, at MIPT in particular, because:

- An Olympiad is not tied to any particular academic course — instead, it covers many undergraduate mathematical courses at a time.
- The problems chosen are relatively hard and are only comprehensible for a small portion of students. At MIPT, this portion is approximately 1% of the students.
- The problems are chosen for their good style and relation to serious mathematics. Exercises in standard techniques are avoided and unexpected ideas are welcome.
- There are no formal consequences after participating in an Olympiad, though informal consequences may be great.

When discussing this topic with my colleagues from Moscow State University (Faculty of Mechanics and Mathematics) or Higher School of Economics (Faculty of Mathematics) I fre-quently hear questions like "Why is this necessary at all?" or "Why are you wasting the students' time instead of just teaching them mathematics?" This means that some explanations are definitely expected here; and I am going to give such. The evident aims of mathematical Olympiads, in my opinion, can be summarized as:

- Bringing together mathematically talented students and making them interact.
- Using advanced-level problems to advertize interesting classical or currently developing topics in mathematics and motivating students for further study.
- Letting students have fun because learning mathematics may seem boring to many of them.

There are some special features of MIPT that make mathematical Olympiads useful there. I am going to give some details. Let me start from the "final destination" of this "Olympic movement" at MIPT: International Mathematics Competition for University Students [1] held every year in Bulgaria. This is the most representative mathematical Olympiad for university students from 1st to 4th year of study; in 2015, it attracted more than 300 participants from more than 70 universities. IMC was established in 1994 by John Jayne, professor emeritus at University College London. At the time, this was a competition mostly between Eastern and Central Europe and former Soviet states. This may seem somewhat narrow but in practice, after IMC expanded in the 2000s to include both hemispheres, it still remains mostly a competition of the former Eastern Bloc countries plus Israel. The reason may be the traditionally deep mathematical education at both school and undergraduate level in these countries. Despite the fact that MIPT mathematical curriculum could be called narrow and old-fashioned, in practice, our undergrads' mathematical training is still better than that at the top-ranking Western universities.

MIPT team has participated in IMC a number of times since 1995, when I myself was one of the contestants and took the first place. Since 2009, our participation is also supported by MIPT rectorate because it is seen as an easy and cheap way to advertise the university abroad. In 2009, our team took the 13th place but once we started going to IMC each year, our results improved significantly, and we now usually finish among the top three. In 2012 and 2013, we even managed to take the first place in the IMC team ranking. The training for IMC and other Olympiads is based on the fact that, besides participating in the already mentioned local Olympiads, students have to do homework. The homework consists of the problems from earlier Olympiads and some nice classical problems. In this homework we try to pay more attention to the areas of mathematics not covered by our curriculum, especially to different sorts of algebra.

When another IMC is coming up, we ask our students to write the solutions in English because at IMC and other international competitions, solutions are to be written exclusively in English, unlike IMO for high school students. Therefore, such competitions also help students get acquainted with mathematical English, which is never taught at MIPT regularly.

I would also like to write about other Olympiad activities at MIPT and give some reasons why they may be useful. MIPT is usually ranked first or second in Russia according to independent benchmarks of the quality of applicants to undergrad programs [5]. So, there is no doubt that MIPT students are of topmost quality. But, unlike Faculty of Mechanics and Mathematics of MSU or Faculty of Mathematics of HSE, MIPT is generally not focused on math; in principle, the students can choose from a wide range of subjects including mathematics (pure and applied), computer science, physics, chemistry, biology, etc. Obligatory mathematical courses are not very deep and mostly cover classical analysis and its branches. All this poses a serious challenge for the professors of mathematics; generally speaking, mathematics has to be actively advertised among the students.

I think it is important to mention some historical facts. MIPT Department of (Higher) Mathematics has traditionally been organizing local mathematical Olympiads every spring, starting no later than 1974. In the years 1974-1990, this competition was step one of the three-stage Soviet mathematical Olympiad for university students, where MIPT team would usually perform well against the leaders from MSU Faculty of Mechanics and Mathematics. Among the Olympiad organizers in the past years were Boris Fedosov, Vladimir Uroyev, Sergey Konovalov, Maxim Balashov, and now myself. More recently, we have started to organize our local Olympiads at the end of every semester, one in December and another one in May. This is convenient both for students because classes are almost over at that time and for professors, who often accelerate end-of-semester exams for students that perform well at the Olympiads.

Our local Olympiads are open to BA and MSc students of all years of study; students from other universities may participate too. Usually there are around 50 participants. Our students also traditionally participate in similar mathematical Olympiads held at Saint Petersburg ITMO in April and at MSU in May.

The problems for our local mathematical Olympiads are collected by several people, including Ilya Bogdanov, Boris Trushin, Oleg Podlipskiy, and Arseniy Akopyan. In fact, MIPT is the headquarters of the Russian Mathematical Olympiad for high-school students and the Russian team for the International Mathematical Olympiad (IMO) [3] and, because of this, MIPT has an appropriate atmosphere, where various Olympiad problems for the school and university levels are continuously discussed and developed.

The students doing best at the local Olympiad have the privilege of going to international competitions in mathematics. Our students usually participate in Vojtěch Jarník International Mathematical Competition [2] in Ostrava, Czech Republic in March or April, and in International Mathematics Competition (IMC) [1] in Blagoevgrad, Bulgaria, held in July or August. The latter has already been described above.

To conclude, I would like to mention some particular students who have performed very well at various Olympiads and are now starting their careers as mathematicians: Pavlo Mishchenko (currently studying at Ecole Normale Supérieure de Lyon), Yakov Kononov, (currently studying at HSE Faculty of Mathematics), and Alexey Balitskiy (currently studying at MIPT and the Institute for Information Transmission Problems of the Russian Academy of Sciences).

References

[1] International Mathematics Competition for University Students.
http://www.imc-math.org

[2] Vojtěch Jarník International Mathematical Competition.
http://vjimc.osu.cz

[3] International Mathematical Olympiad.
http://www.imo-official.org

[4] Roman Karasev's website – Notes on mathematical Olympiads (in Russian among other notes).
http://rkarasev.ru/note/

[5] Ranking of Russian Universities by the Unified State Exam for schoolchildren (in Russian).
http://vid1.rian.ru/ig/ratings/vuzi_top.pdf