Romania helps Uganda on its way to the International Mathematical Olympiad

Sergiu Moroianu

This article reports on an ongoing privately-financed project started in 2019, promoted by members of the Romanian mathematical community, supporting Uganda's participation in the International Mathematical Olympiads.[1]

About the IMO

The International Mathematical Olympiad (IMO) is arguably the most prestigious scientific event for high-school students worldwide, often copied but never surpassed. The IMO model was adopted for other disciplines: Physics, Computer Science, Chemistry, and also for regional competitions: the Balkan Mathematical Olympiad; the European Girls' Mathematical Olympiad; Olimpiada Iberoamericana de Matemática; the Asian Pacific Mathematics Olympiad; the Pan-African Mathematical Olympiad (PAMO), and many others. The IMO is an intellectual competition akin to the athletic Olympics. It evaluates a certain ability to solve elementary level problems quickly. Competitors fight to surpass themselves, not against other participants. Between the ages of 12 and 18, aspiring IMO participants dedicate most of their free time to preparing for the IMO. They are trained by professional trainers, and their work is mainly driven by inner motivation.

Many successful mathematicians never participated in Olympiads, while many former IMO participants choose various other professions later in life. Nevertheless, the IMO – and elementary math competitions in general – play an outstanding role in raising awareness about mathematics and about our profession among young students during the decisive years of their intellectual formation.

A brief history of the IMO

The IMO is an Eastern European cultural product. The first IMO took place in 1959 in the mountain resort of Sinaia, Romania, involving students from just seven countries from the former Eastern European bloc.[2] Since 1959, it has grown steadily to the point where no less than 115 countries were represented at the 60th edition in England. A notable forerunner of the IMO was the yearly competition organized by the *Gazeta Matematică*, the oldest periodical publication in elementary mathematics worldwide, published uninterruptedly in Romania since 1895, even during the two world wars. In the first twenty years, Eastern European bloc countries dominated the competition, but today students from Australia, Canada, France, Iran, Italy or Vietnam compete successfully with the Eastern European students from Bulgaria, Hungary, Poland or Ukraine. The explanation for the continuous success of some countries lies in the professional methods of selection and training described below. These methods yield spectacular results wherever they are adopted.[3] The countries with the strongest overall performance at the IMO are China, Russia, and the US.

Training and selection for the IMO: The case of Romania

Romania selects future IMO participants from all middle schools around the country. Starting in fifth grade, students are encouraged to solve four Olympiad-type problems each month from the *Gazeta Matematică*. The first two stages of the annual math Olympiad are attended by thousands of the best students in the country. Secondary school teachers receive favorable evaluations when their students qualify for the higher stages of the competition. In most cities, extracurricular excellence clubs are organized weekly, supported financially by the Ministry of Education or by private foundations. Teachers in top schools train their gifted students far beyond the official curriculum. Numerous training camps, clubs, and online training programs take place every year. Coaches for the Olympiad are often themselves former IMO participants. Through this inclusive approach, not only do we select native talents from the maximal pool of 200,000 students in each age group, but we then train them over a long period of time. Participation and training costs are covered by the state. Olympiad winners receive prizes as well as scholarships and admission offers to universities.

[1] www.imar.ro/~sergium/mathuganda/new_mU/index.html
[2] imof.co/about-imo/history/
[3] www.ams.org/notices/200810/fea-gallian.pdf

Like in sports, results at the IMO are directly correlated with the material effort invested by society in young competitors. I need not argue here the merits of having a mathematically-literate workforce. I only mention that in recent years a growing share of Romania's GDP is produced by the vibrant IT industry, made possible in part by the public's 125-year-old obsession with elementary math competitions.

The IMO in developing countries

Developing countries have taken a more sinuous path in adapting to the IMO culture. Some – Thailand, Korea, Singapore, but also Peru, Colombia or Brazil – now have a solid tradition, and their rise in IMO rankings follows that of their GDP/capita. Others have been less successful. Until 2010, no country from "Black Africa" – that is, outside of the Maghreb and South Africa – had ever participated in the IMO. Only 10 out of the 54 African countries participated in IMO 2020, but 6 of these sub-Saharan: Nigeria, Ghana, Kenya, Tanzania, Botswana and Uganda.

There are obstacles these days for a new country to start attending the IMO. Firstly, IMO problems become harder every year. Here is the first problem from the first IMO in 1959: *Show that the fraction* $(21n+4)/(14n+3)$ *is irreducible for any natural number n.* This exercise is today accessible even to a good sixth grade student! As years go by, it becomes more and more problematic for a country lacking a pool of former IMO participants to obtain good results fast enough in order to justify further participation.

Other difficulties are of a more practical nature, hard to understand in privileged countries. The leadership of some poorer countries does not see any financial benefit in supporting the Olympiads; others simply cannot afford the expense, while in some extreme cases, there can be countries which invest in selection, train their team, and pay for plane tickets, only to find themselves unable to attend the IMO for administrative reasons. This was the case for the Nigerian team, which in 2019 had a student on whom they placed high hopes of winning at least a bronze medal. Sadly, due to bureaucratic issues, the team's visas for the United Kingdom were not issued until after the competition was over.

The mathUganda project

In 2018, I was one of the coordinators at the 59th IMO in Cluj-Napoca, Romania. I spoke to half of the team leaders from all over the world, taking the opportunity to inquire about the Olympiads in their countries. One of these leaders was Jasper Okello, the initiator of Uganda's participation in the IMO. Before 2018, Uganda had received a Honorable Mention at the IMO twice. The best ranking of the team had been in 2017, where it was in the bottom 14.55 %. I learned that the Ugandan state does not support students' training or participation in the IMO. I was particularly struck by the fact that the Uganda Mathematical Society had not even been able to obtain support for participation from any international bodies such as the IMU. Together with Jasper, we began sending out funding applications to various charities or learned societies. I also contacted acquaintances in academia, but with no success. It seemed that public funding from rich countries is simply not aimed at talented young people in countries like Uganda.

I finally opened a private online donation list. I estimated the total participation cost for the team as around 10,000 euros, of which I expected to raise 10 %. The response was overwhelming. Donations started to pour in from family, friends, colleagues, and even strangers who learned about our project. We reached the initial target in under three weeks. The Romanian Society for Mathematical Sciences became involved in the project. Colleagues with solid experience in IMO training offered online lessons. By June 2019, we had transferred $8,000 to the Uganda Mathematical Society. Thanks to our help, Uganda was able to send a complete team of six students to the IMO 2019. They purchased their plane tickets early enough to submit visa applications on time, unlike the less fortunate Nigerian team.

At the IMO 2019, Uganda presented a team of three girls and three boys, which had won three bronze medals at the Pan-African Mathematical Olympiad (PAMO). This team ranked 102nd out of 112 participating countries. Out of just 5 points obtained by Team Uganda, 2 were due to Eva Kakyo, who was initially a reserve. Eva's trip to IMO 2019, and consequently the team's result, were possible thanks to the generosity of our Romanian sponsors.

Kampala training in 2020

Encouraged by our project, Jasper Okello applied and succeeded in getting Uganda included in an MIT IMO-training program already implemented in Ghana in 2019. A team of three MIT students, including a former gold medalist at IMO 2018, conducted the IMO selection camp in Kampala in January 2020.

In February 2020 I traveled in Uganda for two weeks at the invitation of the Mathematics Department of Makerere University, the oldest higher education institution in East Africa. I returned home just one week before the borders closed during the pandemic.

Most of my time in Kampala training the IMO and PAMO teams placed emphasis on synthetic geometry: similarity, the circle, cyclic quadrilaterals, intersecting secants, polar lines. We also touched on recurrent sequences, inequalities (Cauchy-Schwarz, AM-GM), number theory, and functional equations.

Traditionally, geometry is Uganda's strong field. To achieve excellence on this topic, I reviewed the whole theory starting from the axioms – the three cases of congruence and parallelism. I had already noticed in 2019 that students tended to learn results "by rote". They needed several good minutes to re-discover the proofs for the sum of the angles in a triangle, the properties of isosceles triangles and of the parallelogram, concurrence of important lines, similarity, and the Thales theorem. We continued with the properties of angles inscribed in a circle and with cyclic quadrilaterals. From that point, the students took off! We began to solve problems in the "IMO training" format as I know it: I would hand

Uganda's PAMO and IMO teams, Makerere University training camp, February 2020

them a list of 2–3 problems, the student who solved one of them had to explain it to the others, and if needed I would rephrase the proof with more details. The first lists of problems were at the level of middle-school Olympiads in Romania, then we advanced to problems from PAMO, the Balkan Olympiad and even the IMO itself. There was a moment of catharsis when I first (casually) told them that the problem they had just solved was from some IMO back in the 2000s. The light in their eyes was priceless!

Most of the students came from middle-class families. The exception was Jesse Enkanya, the son of a former member of Parliament. At no time did I detect any attitude of superiority from him. In fact, all the Ugandan students left a very positive personal impression on me. It was also impressive to observe them solving hard problems from 8 to 5 every day for two weeks in a row, without ever showing any sign of fatigue. This is a most encouraging indicator of what their younger colleagues might achieve if they start training for the IMO at an early age.

Uganda's results at IMO 2020

Jesse Enkanya was the first competitor from Uganda ever to place in the second tier of competitors (i.e., better than 35,93 % of the participants). Richard Ayebare (who will attend MIT starting next fall) and Jonathan Ngabirano also obtained Honorable Mentions. Together, Jesse, Richard and Jonathan solved three problems, surpassing the cumulative performance of Team Uganda from 2012 to 2019.

The team ranked 87th out of 105 participating countries, better than Algeria, Morocco, Chile or Costa Rica, countries significantly richer and mathematically more advanced. Compared to 2012 or 2013, the qualitative leap is impressive.

Due to the pandemic, IMO 2020 was organized online in September. Jesse took the exam in an accredited examination center in the United States, where he is currently enrolled as a freshman at the University of Illinois. The other five students attended the competition from Kampala. I was able to use the balance of $1,500 on the project's account to purchase surveillance equipment in line with the security conditions imposed by the organizers.

I myself tried out Problem 1. As soon as I managed to draw an acceptable picture, I had a happy premonition: that problem was going to be approachable with the cyclic quadrilateral methods we had thoroughly covered during the Kampala training camp! From my direct experience with the team, I believed they would be perfectly able to solve it. And indeed, the final result was in line with what we knew about their abilities.

Conclusions

The *sine qua non* success factor in any competition is participation. Uganda's participation in the IMO is thanks to Jasper Okello, a mathematics teacher at Nabisunsa Girls School in Kampala. Jasper has been the driving force behind this project for 10 years. The first attempts were a bit frustrating, as Uganda's team scored close to zero points. The prohibitive cost of travel was not covered by the state, while sponsors from a developing country are understandably reluctant to finance a contest where the team does not have good prospects. But in the long run, his efforts paid off. After ten years of hard work, Uganda established itself as a regional powerhouse in elementary math competitions at IMO 2020.

As a former IMO participant, I know from first-hand experience how motivating it is to compete as part of a team with a strong track record. But how demoralizing failure can be … How tempting it is to throw in the towel, to admit that you stand no chance against the Europeans or the Chinese, that you will make a fool of yourself! Kudos to Jasper Okello and to Uganda's students for braving this risk.

I should mention the role of Andrew Tugume (honorable mention at IMO 2017) in preparing the team. Andrew, currently an Engineering student in Kampala, delivered an excellent Geometry lesson in my presence. He was the team's main coach in the months before the contest. Although Uganda cannot count on many former IMO participants, having Andrew is precious. I hope he will stay involved.

The mathUganda project continues. I am in contact with mathematicians planning to organize a joint IMO training network for East African countries. We have already raised more than $5,000 for the IMO 2021. Radu Bumbăcea, Dragoș Manea, Flavian Georgescu, Liviu Păunescu and Lucian Țurea, trainers of Romania's IMO team, offered online lessons. I take this opportunity to thank them and our donors for their generosity. It seems that the idea of helping smart students from a distant country, for an intelligent purpose, touched a secret chord in our community.

Promoting mathematical education is a credible strategy for lifting countries like Uganda from poverty, and the IMO is an excellent ambassador for our discipline among the young generations. Our project demonstrates that Europe has the expertise and the will to spread the passion for mathematics in developing countries.

Sergiu Moroianu is a researcher at the Institute of Mathematics of the Romanian Academy in Bucharest, and a former IMO gold medalist. His research interests are in Differential Geometry and Global Analysis.

sergiu.moroianu@imar.ro

fFSB
fundació FERRAN SUNYER I BALAGUER

Call for the
Ferran Sunyer i Balaguer Prize 2022

The prize will be awarded for a **mathematical monograph** of an expository nature presenting the latest developments in an active area of research in mathematics. The monograph must be original, unpublished and not subject to any previous commitment edition.

The prize consists of **15 000 €** and the winning monograph will be published in the **Birkhäuser** series "Progress in Mathematics".

DEADLINE FOR SUBMISSION:
December 3, 2021, at 1:00 pm
http://ffsb.iec.cat

ADVERTISEMENT