Deputy Leader's Report on EGMO 2023

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The European Girls' Mathematical Olympiad is an annual mathematics competition in the Olympiad style for secondary school and sixth form girls. The 12th edition of EGMO was held from the 13th to the 19th April 2023, in Portorož, Slovenia. This is a report on EGMO 2023, from the perspective of the deputy leader.

Daily Diary

Day 0

My EGMO starts the day before the girls', catching the train from Lyon to Paris and then the overnight bus to London. Because of the strikes[1] my train gets changed twice, and so I end up with four hours to kill in Paris. A little bit of midnight sightseeing takes place.

Day 1

I catch my bus at silly-o'clock in the morning, and try and get some sleep. The sleep is notably D tier. I cannot recommend the FlixBus to anyone travelling from France to the UK. After an S tier kip on a sofa on the ferry, I arrive in London in the morning. I spend a little time in St Pancras memorising everyone's allergies before boarding the train to Luton.

The leadership this year consists of our leader Kasia, who has been EGMO deputy for a number of years, myself as deputy, who has been involved in UKMT activities for a good while now, and pastoral observer Jenni, for whom this is the first international trip on the leader side of things.

Everyone arrives in good time to Luton, which is great because our flight is delayed by nearly two hours. Kasia distributes the lovely purple hoodies and we quickly realise it was an excellent colour choice: they look awesome, and they're visible from a mile away. Nobody is getting lost on this trip.

[1] Macron is trying to do some pension reforms, and in doing so has run French democracy over with a bulldozer. People are very angry.

I have a B tier nap on the plane, and we land in Slovenia. A long coach ride to the sea follows, along with a C tier nap. We arrive at around 1AM, check in[2], and go to sleep.

Day 2

This morning the girls have a treasure hunt, and I catch up on some sleep[3]. The hotel is excellent and the food on offer is similarly excellent. After lunch I go and chat to Melissa, a very good friend and EGMO medallist from 2017 and 2018, who now works for Jane Street. They have sponsored EGMO very generously, and are presenting a whole host of fun activities for the girls to do in their free time.

The opening ceremony takes place later, and Kasia, Jenni, and I score horribly on Opening Ceremony Bingo. There are no speeches in Slovenian (except one by the President, which is translated in real-time), no folk dancing, no speech by someone who doesn't know what they're talking about, and nobody saying they were bad at maths in school. Instead, we are delighted by the words of the first female President of Slovenia who is an accomplished academic, a Minister for Education who was an IMO Leader back in the day, and the rector of the University organising EGMO. The master of ceremonies provides the comic relief, but even his maths jokes are pretty well researched. During the parade of teams, the percussion band STOP wows us all and the master of ceremonies introduces each country with slightly repetitive stereotypes.

Day 3

The first day of competition arrives, and I try the problems in a room with the other deputy leaders. My first thoughts are that Problem 1 is way too difficult and Problem 3 is too easy. These thoughts are confirmed by pretty much everyone else.

As the girls come out, Kasia is still stuck in a jury meeting to decide the markschemes so Jenni and I take the girls to lunch. Two are claiming all three problems and are in great spirits. One is claiming one problem and one is claiming no solutions, and these two are a little deflated. Thankfully, a good lunch does wonders.

The EGMO organisers have organised some wonderful de-stress activities for the afternoon, so the girls and Jenni have fun with arts and crafts. Kasia and I head to the hotel pool before picking up the scripts. Jenni joins us for some marking and we quickly realise that Elsa's question 1 is essentially complete despite her claiming zero solutions, which is a great relief.

[2]Unfortunately, members of other delegations do not seem to understand the concept of waiting their turn for the check-in desk. Thankfully, sleep-deprived Emily is someone who will not take any nonsense.

[3]A tier.

Day 4

I give the girls a quick summary of the previous day at breakfast, and we head on into the second exam. Today's paper is much more suitable, with some easy combinatorics which is actually easy, medium number theory which is actually medium, and hard geometry which is really difficult.

Everyone comes out feeling pretty confident, but we're fairly sure the medal boundaries will by very high.

During marking we realise that Huyen, who was claiming a score of 0-0-7 for the day, actually merits something more like 5-3-7, which is wonderful to see. Less lucky is Aanya, who's made a gravely wrong assumption on question 4 which will cost her heavily.

We spend the evening letting the girls know what we're going to ask for, and playing some silly games.

Day 5

The girls and Jenni are whisked off on a trip to Ljubljana, and Kasia and I prepare for war. This is my second time coordinating, but the first where I'll actually have to do any work[4].

I learn a multitude of things from Kasia this day, including:

- If there's any hope of justifying an extra mark, ask for it. The worst the coordinators can do is say no.
- If the previous team finish early and the next team hasn't gone in yet, you can just ask to coordinate then and there. Everyone likes to be efficient.
- Re-read your students' scripts six times. This will help you be efficient in coordination.
- Nobody is perfect, and you will most likely miss at least one mistake a student's script even after having read it six times. You have many, many hours in the coordination day to fix the mistake, and to justify why the script deserves as many marks as possible.
- Don't ever volunteer for the Appeals Committee.

Problems 1, 2, 3, and 6 finish very quickly, but problems 4 and 5 take a very, very long time. Coordination for problem 4 finishes at around 8PM. After this the girls come over to the hotel where coordination is taking place. Having solved many problems, and having seen the scoreboard and the likely medal boundaries, nobody's in particularly good spirits. In a normal year, scores of 35, 32, 22, and 21 would merit two golds and two silvers, but this year they're certainly going to merit two silvers and two bronzes.

I'd like to take this opportunity to remind any young mathematician that representing the UK at an international maths competition is the stuff of dreams, and that if and when you

[4]My first time coordinating was at the remote Balkans in 2021, where I asked for some scores and they said 'yes.'

get there, a medal of any colour is something you will treasure until the day you die. The end of coordination day is a chance to look back at every little step you took to get there, from learning geometry diagrams in your bedroom to your first ever camp where you knew nothing and got zero on all the exams. When you reach the top of that mountain, don't let your aching legs stop you from admiring the view.

We get the girls to admire the view, and then they head to bed. Kasia has volunteered for the Appeals Committee so I am sent to the final Jury meeting to deputise.

The meeting begins with some formalities followed by a report on a suspected irregularity from one country. Some very constructive conversations ensue, and the whole affair is handled very well. The Jury votes almost unanimously to dismiss the allegations. It then follows with some more formalities, and we then discuss whether or not to update the EGMO General Regulations with regard to transgender students. The discussion is generally positive, and the decision is taken to not change anything just yet, the general vibe being 'we'd like to make the competition welcoming for trans students but we're not qualified to explicitly define the concept of gender.'

After this the Appeals Committee emerges, and Kasia is utterly exhausted. The medal boundary vote is thankfully not very contraversial and our students are each squarely in the middle of a bracket, so nobody's adversely affected.

We eventually finish at around midnight, and I remark that that's pretty standard for EGMO. Apparently it's not pretty standard for EGMO. The only other time the Jury has finished at midnight is the only other time I've been to EGMO. It seems I'm just cursed.

Day 6

After the stress of coordination, and an underwhelming trip to Ljubljana yesterday, Ema is the only student keen to go on today's excursion. Jenni also wants to stay behind, so myself and Kasia go with Ema to Postojna Caves. These are some of the most magnificent caves imaginable. They put the Peak District to shame. Hundreds upon thousands of stalactites and stalagmites line the walls from spaghetti strands to metre-thick towers. Particularly admired are the 'big stack of dinner plate' stalagmites and the 'hollow straw' stalactites.

We arrive back for lunch and debrief the girls individually on their whole EGMO, and what to work on for the future. We then dress up for the closing ceremony. Everyone comes out looking very smart: it seems Aanya's advice to 'bring something nice' was paid attention to. A quick bus ride to the venue, then it's time for the ceremony.

Our old friend, the master of ceremonies from the first day, has returned to lead us through the end of EGMO. Unfortunately, nobody's told him that the scores are not secret. He thinks there is big suspense and drama. There is neither suspense nor drama. Our girls go up one by one to collect their medals, and the deflation of yesterday is utterly forgotten. All four seem to be over the moon. Kasia, Jenni and I are too. There's a bizarre prize of 'a handshake from Geoff' for the Ukrainian team who won the overall competition, and it would later turn out that the actual prize had been misplaced, but was handed over shortly after.

We head over to the leaders' hotel for the farewell dinner, at which point the exhaustion sinks in. EGMO is over, and the girls have nothing to stress over, and the adults' sleep deprivation kicks in. I head to bed at around 9pm. There is mild chaos later, which I just sleep through.

Day 7

On the plane on the way home, I sit an exam of my own - the 'français comme langue étrangère, niveau B2' exam that I missed on the Monday. This is not your average Duolingo test. There's political commentary analysis. Imagine GCSE English Language, but it's all in French instead. After seven months in France, it's refreshing to see that I'm actually semi-competent at the language. Kasia helpfully reminds me that a laugh is masculine and I finish up as we land.

We say our goodbyes in Gatwick Airport, and I grab a meal deal before heading to the train station only to find that the whole station is closed and there's no hope of it reopening any time soon. Jenni and I quickly go back to being mother hens and guide our confused flock through different options. After an hour or so of weighing up our choices we head to the taxi rank where we are helpfully told that the trains to London are about to reopen. We all pile onto the second train to Victoria, and part ways there.

Problems

Day 1

Problem 1. There are $n \geq 3$ positive real numbers $a_1, a_2, \ldots, a_n$. For each $1 \leq i \leq n$ we let $b_i = \frac{a_{i-1}+a_{i+1}}{a_i}$ (here we define a_0 to be a_n and a_{n+1} to be a_1). Assume that for all i and j in the range 1 to n, we have $a_i \leq a_j$ if and only if $b_i \leq b_j$. Prove that $a_1 = a_2 = \cdots = a_n$.

Problem 2. We are given an acute triangle ABC. Let D be the point on its circumcircle such that AD is a diameter. Suppose that points K and LL lie on segments AB and AC, respectively, and that DK and DL are tangent to circle AKL. Show that line KL passes through the orthocentre of ABC.

The orthocentre of a triangle is the point of intersection of its altitudes.

Problem 3. Let k be a positive integer. Lexi has a dictionary $\mathcal{D}$ consisting of some k-letter strings containing only the letters A and B. Lexi would like to write either the letter A or the letter B in each cell of a $k \times k$ grid so that each column contains a string from $\mathcal{D}$ when read from top-to-bottom and each row contains a string from $\mathcal{D}$ when read from left-to-right. What is the smallest integer m such that if $\mathcal{D}$ contains at least m different strings, then Lexi can fill her grid in this manner, no matter what strings are in $\mathcal{D}$?

Day 2

Problem 4. Turbo the snail sits on a point on a circle with circumference 1. Given an infinite sequence of positive real numbers $c_1, c_2, c_3, \ldots$ Turbo successively crawls distances $c_1, c_2, c_3, \ldots$ around the circle, each time choosing to crawl either clockwise or counterclockwise.

Determine the largest constant $C > 0$ with the following property: for every sequence of positive real numbers $c_1, c_2, c_3, \ldots$ with $c_i < C$ for all i, Turbo can (after studying the sequence) ensure that there is some point on the circle that it will never visit or crawl across.

Problem 5. We are given a positive integer $s \geq 2$. For each positive integer k, we define its twist k' as follows: write k as $as + b$, where a, b are non-negative integers and $b < s$, then $k' = bs + a$. For the positive integer n, consider the infinite sequence $d_1, d_2, \ldots$ where $d_1 = n$ and d_{i+1} is the twist of d_i for each positive integer i. Prove that this sequence contains 1 if and only if the remainder when n is divided by $s^2 - 1$ is either 1 or s.

Problem 6. Let ABC be a triangle with circumcircle Ω. Let S_b and S_c respectively denote the midpoints of the arcs AC and AB that do not contain the third vertex. Let N_a denote the midpoint of arc BAC (the arc BC containing A). Let I be the incentre of ABC. Let ω_b be the circle that is tangent to AB and internally tangent to Ω at S_b, and let ω_c be the circle that is tangent to AC and internally tangent to Ω at S_c. Show that the line IN_a, and the line through the intersections of ω_b and ω_c, meet on Ω.

The incentre of a triangle is the centre of its incircle, the circle inside the triangle that is tangent to all three sides.

Results

Name	P1	P2	P3	P4	P5	P6	Total	Medal
Aanya	7	7	7	2	6	3	32	Silver
Ema	7	7	7	7	7	0	35	Silver
Elsa	6	1	0	7	7	0	21	Bronze
Huyen	0	7	0	5	3	7	22	Bronze
Max	7	7	7	7	7	7	42	wow!
Min	0	1	0	2	3	0	6	oop

The medal boundaries were 38 for gold, 28 for silver, and 16 for bronze.

For all except Aanya, this was their first competition, and all will be eligible for EGMO next year as well. It's pretty clear that each girl played to their individual strengths, hence the excellent score from Max and the very low score from Min[5]. Students are reminded that 'being bad at geometry' is an overused character trait, and you should try to avoid making

[5]Max is the contestant who gets the best score among the students on each problem, and Min gets the worst on each problem.

it your entire personality. With that in mind, I was very happy to see that everyone spent at least some time on question 2, and nobody scored 0 on that problem.

Formalities

Small changes to the regulations

The Jury voted on the following changes to the regulations:

- All the rules introduced to account for COVID have been removed.
- Watches are no longer permitted in exams.
- Coloured pencils are okay.
- Correction fluid is not okay.
- Scores will only become public knowledge once girls are back from excursions, to avoid them checking their phones every 3 seconds.
- Small countries can team up to send a joint delegation if they want to.

Suspected irregularities

It was brought to the attention of the jury that the scripts of a country on Problem 6 were unusual. In particular, they had three perfect solutions and one almost-perfect solution, with seemingly no rough work, no markings on their diagrams, and no crossing-out of incorrect lines. All four solutions were completely different. The country's leader was then invited to respond to allegations of a suspected irregularity, and did so very professionally. We were then invited to look through some of their scripts for other questions, look up the country's international record for geometry, hear from the coordinators about the neatness of the country's other scripts, and ask questions.

To me, it was not at all clear whether or not an irregularity had occurred. However, some words from the Bulgarian leader set the tone for the vote. A student from Bulgaria was accused of improper conduct at the IMO in 2001 in Washington, though the affair was never resolved because the Jury spent too much time voting about how to conduct a vote. She explained how despite no conclusion being reached, the student never touched mathematics again, and the shame of the scandal lives on to this day within the Bulgarian Olympiad community. She urged that unless we were absolutely sure that something underhand had occurred, we should vote to dismiss the allegations.

The Jury voted to dismiss the allegations almost unanimously. In my view, the whole process was managed excellently, from the first report, to the leader's response, to the questions asked and the answers given.

Gender at EGMO

Another thing brought to the Jury was whether or not to make clearer the gender-based criterion for competing at EGMO. Currently, the General Regulations state 'Contestants must be female' and 'Each invited country is entitled ... to send a team consisting of up to four contestants'. EGMO in general cannot dictate how the countries choose their teams, but there was a proposal to specify a 'loosest possible criteria for who is eligible', which would have been some combination of 'anyone identifying as female,' 'anyone not identifying as male,' and 'anyone assigned female at birth.'

Many people contributed to the discussion, with ideas on how to make EGMO welcoming and suggestions from their own national girls' Olympiads. The general consensus was that 'the EGMO Jury is not qualified to define "female", and the General Regulations will do as they are for now, but we'll keep this discussion in mind for the future.'

I should add, for any young trans mathematician who is keen to compete at EGMO, that the discussion was overwhelmingly positive. Many leaders were keen to share their experiences of how they managed to simplify the process for trans students competing in girls' national Olympiads. For example, the Mexican leader brought up the example of the Mexican girls' interstate Olympiad, which follows a very similar format to EGMO. For this contest, any team Leader wishing to bring a student whose documentation doesn't say 'female' should write a little note to the Jury asserting that they're not male, and that's that. Though no decisions were taken this year at EGMO, I can imagine that, if a decision is ever taken to update the General Regulations, it will be something very similar.

Final remarks

My second EGMO, and my first on the adult side, was a joy in every way. My thanks to Kasia and to Jenni for being wonderful travelling companions and brilliant friends. Thanks to the students for making the week so lively, and for making us so proud. Thanks to everyone at the UKMT office for getting us here in one piece. To the organisers of EGMO, thankyou for all the effort you put in to make this edition successful, and to Tina, our team guide, thankyou for being by our side all week. The biggest thanks go to everyone who's volunteered for the UKMT in the past few years for building the tower on which our students now stand.

It was during my first year as a student on the Olympiad circuit, my first year of sixth form, that I realised how male-heavy the world of maths is. As I've got further and further up the ladder, from undergrad to masters and now to PhD, I've seen it get worse and worse. It can be so frustrating to sit in a room, looking around at the rows and rows of men, and wonder where all the women that should be in that room have gone to, and why they're not by your side. At EGMO, nobody wonders that, because they're all there, by your side. EGMO is the chance, for one week a year, to dream of what the world would be like if gender inequality were reversed, and to live in the kind of environment that men in mathematics get to live in the other 51 weeks of the year. EGMO is also the chance, step by step, to convince girls

that this is a world that they belong in.