

Balkan Maths Olympiad 2016 - Student Report

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Introduction

This year's Balkan Maths Olympiad was held in the beautiful capital city Tirana, Albania from the 4th to the 10th of May. The UK team did incredibly well, and everyone had a wonderful time. From a student perspective and with the aid of multiple photos, this report hopes to detail the many interesting events that occurred; not only those that went well, but also those that went a bit wrong.

Scores

The medal boundaries were 17 for a Bronze, 30 for a Silver and 32 for a Gold.

Code	Name	Q1	Q2	Q3	Q4	Total	Medal
UNK 1	Jamie Bell	10	0	10	2	22	Bronze
UNK 2	Rosie Cates	10	1	10	0	21	Bronze
UNK 3	Jacob Coxon	10	1	9	0	20	Bronze
UNK 4	Michael Ng	10	9	10	1	30	Silver
UNK 5	Thomas Read	10	10	9	0	29	Bronze
UNK 6	Renzhi Zhou	10	10	10	0	30	Silver
Total		60	31	58	3	152	

We scored a total of 152, the highest score for any UK team at the Balkans, and furthermore, everyone won medals; a fantastic achievement. I am fully aware that most readers will not want a detailed analysis of the scores, so for those who do, see Appendix 89.

Events

Wednesday 4th May

Arriving at Gatwick Airport North Terminal about two hours early, I look for the promised congregation point - 'Costa Coffee'. The fact that there are two of these on separate floors is highly unhelpful, but fortunately we all manage to meet at one of them at 2:50. Dominic hands out this year's Balkan T-shirts (a stylish black and white!), and whilst we check in, Gerry gives us an interesting cuboid problem.

Strangely both Renzhi and Jacob are selected for further investigation at security, but thankfully all is fine. Apart from a few screaming children, the three hour flight is rather pleasant, and the time is mostly spent doing problems. Some Albanians are sat in the row in front, and they engage in jovial conversation with us, remarking that in Olympiad problems, there are 'more letters than words'. Indeed.

After a minor earthquake, i.e. the landing of the flight, we have the briefest of waits of almost an hour as the Albanian airport staff finally decide to start arriving. Passports are dealt with in the slowest



Figure 1: Everyone knows that the aeroplane is an excellent place to do maths.

way possible, giving us more time to solve a particularly challenging problem about orthocentres in a rectangle. It turns out that we are last in the queue, and after luggage collection, we walk to a beautiful airport hotel where we will be staying for one night. There we meet our friendly guide Sebastian, a university student who speaks excellent English and is very helpful.

By this time, we are all starving, so we satisfy ourselves mentally with a discussion of the notorious 'Butterfly Theorem'. Dominic makes the excellent suggestion to order some food from the restaurant, and Gerry gets Fried Squid instead of Lamb Ribs. The words 'Squid' and 'Ribs' are probably quite easily confused. We go up to our rooms, start to minimally unpack, and find a surprise. Perhaps we are not too familiar with Albanian culture, but even so, a full size window allowing people to look into the shower is quite strange indeed!

Thursday 5th May



Figure 2: Some of us wear our newly acquired caps.

I have slept poorly, and gaze at the clock on my phone waiting for the alarm to ring. On the contrary, the others in my room have slept well, and Renzhi continues to sleep whilst I take a shower (with the curtain down). At 8:30 we decide to eat a leisurely breakfast, and find that Jacob, Jamie and Rosie

are already half finished! No-one particularly likes (or eats) the brownish yellow ‘Albanian Speciality’ and Renzhi finds a nice solution to the orthocentres problem on the sofas in the lobby.

At 10:30, we leave the airport hotel and arrive at the student site; a four star hotel named ‘Hotel Continental’. The sun shines down in radiant beams, illuminating the front of the building with a warm, amicable aura. The perfect photo opportunity.

We each get our rucksack of freebies including a cap, pen, notepad and of course, an Albanian Balkan MO T-shirt. Since we are given many ‘extra large’ T-shirts, we decide *wisely* to switch them to smaller sizes. With some time to kill before the other countries arrive, Sebastian takes us on an excursion. Off we travel to Mount Dajti, a long, arduous journey due to the inability of cars to obey the basic highway code. Indeed, for some reason cars love to drive over pedestrian parts of the road in Albania, and overtake at any time possible. The walls are littered with graffiti, varying in offensiveness and language. We are keen to take photos.



Figure 3: ‘Stay Weird’, but don’t forget to look for wolves.

We arrive at a cable car station, and Sebastian manages to secure us free tickets; the journey is beautifully scenic, although we struggle to see through the many ominous scratch marks in the glass. At the base of the mountain, we decide to walk along a route marked with white and red signs and 40 minutes later, we find ourselves at a beautiful local maximum. Using our infallible spatial awareness as a group, we miss a path on the way down and unknowingly pass through a military zone. No-one is shot, fortunately.

Dominic goes off with Sebastian to sort out something, so the students race onto the merry-go-round in a nearby playground for some nauseating fun. Rotating normally at high speeds is obviously not exciting enough for us, so we start turning our heads 90 degrees clockwise and anticlockwise. At two, we walk to the Balcony Restaurant where Jacob orders the Albanian traditional ‘Roasted Lamb Entrails’. Unfortunately there are none available and considering how popular that dish must be, this of course comes as a great surprise. Dominic suggests that we should get some salad, and the waiter brings three immensely filled bowls.

The other destination of our short trip turns out to be an innovative museum named ‘Bunk-Art’, not ‘Bunker’, as one might guess by ear. This was indeed an old Albanian bunker refurbished with rooms detailing parts of the war. We return to the student site on a minibus and Dominic, being our leader, is mysteriously separated from us for two days.

Chaos happens at the hotel. When the organisers received the name list in advance, they confused the name ‘Rosie’ as a boy and apparently Renzhi was non-existent. After extensive room reallocation, repeated travelling up and down on staircases and changing room keys four times, we finally settle;

the five boys in one room, and Rosie in another. The room is comfortably spacious with a gathering area, and Rosie joins us there.

But all is not fine. For we are lacking of one bed. The cleaners come to sort out the problem, and, thinking that Rosie is staying with us, assume that we are missing two beds, and much confusion ensues. In the end, they bring one camper bed, and apologise, saying that two will have to share the double bed. But of course, now everything is fine. Fine indeed. At dinner, the waiter fails to understand that Jacob has a gluten allergy, and this leads to even more confusion. Eventually everyone has something to eat, and we return to our room to do some maths. After a while, Rosie finds that most of the beds in her room have been stolen by other rooms, and we start to sort out bedding arrangements.



Figure 4: The stuff of nightmares.

Ending up with the camper bed I quickly deduce that something is wrong. Inside the mattress, the springs are in total disarray, arranged to provide maximum pain to the user's back, and as I lie down there is a excruciating, cacophonous crack; a half broken wooden board has just given way underneath me. Another wooden board fails when others experience the horror for themselves, rendering the bed almost impossible to sleep in. We fold it up, discreetly preparing it for its grave, and indeed, two of us have to share the double bed; soon we start to sleep, having set our alarms at 7:00.

Friday 6th May

We get up at 8:00. The cleaners see the broken bed and ask if a bomb has landed in our room ("Bombal?"). Breakfast is refreshing and the organisers ask us to wear our newly acquired Albanian Balkans T-shirt for a photo. For some reason, Albanian T-shirt sizes are about twice as small as British ones; a fact that we realise only when we try to put them on. After a very swift photo, we gladly change back into the British Balkan T-shirts and take a brisk walk to the Opening Ceremony venue for 11:00. We enjoy many speeches, photos, folk dancing, and some *cheer-leading* from the Harry Fultz Institute.

After lunch and afternoon mathematics, we relax in the outdoor bar. Sebastian joins us in a card game, and we decide to play Mao, in which he does surprisingly well. He then shows us an Albanian card game - 'The King on the Hand'. Rosie and myself are subject to interesting forfeits, which I shall not disclose in order to preserve our dignities...

In the evening, we eat dinner, which possibly includes some goat meat, and we take an early night.



Figure 5: Varying levels of enthusiasm in the Opening Ceremony.

Saturday 7th May

Today is the day of the exam. We wake at a horrific 5:50am and sluggishly travel to the Harry Fultz institute, our exam venue. Upon arrival, we curiously peruse the *Physics* equations on the banners and stare at the large bus that becomes stuck reversing. For a statement of the problems, see [here](#).

Most of the team solve Q1 and 3, with varying success on Q2 and 4. For Q2, Thomas and Renzhi have trig bash solutions, and I have a synthetic one using enlargement. Jamie is the only UNK to discover a fundamental 'diamond' shape in Q4 of the correct size, with a proof that all squares inside are of unique colours; a result that will surely get him partial marks.



Figure 6: How teenage mathematicians play on a slide.

We return to find that all the room keys have stopped working and quickly consult the reception. We find that Albanian television is rather entertaining, especially the Albanian version of 'Hole in

the Wall' and visit the local playground for some more active entertainment. We are all dejected to find no merry-go-rounds, but we still greatly enjoy ourselves on the slides (both going down and up!) and the monkey bars; thankfully no-one gets stuck in the children's swings.

Following the excitement of yesterday's card games, we play Liar's Poker with Sebastian and soon afterwards, another guide named Elvis joins us. He teaches us 'Resistance', which we enjoy immensely, and this continues late into the afternoon. I speak with some Macedonians whom I met on the bus and Gerry shows us the official solution to Q2 involving the nine-point circle. After dinner, we watch Shrek in Italian (surprisingly interesting!) and then sleep.

Sunday 8th May

Breakfast is served at 7, and we see Dominic, who stays at the hotel to do coordination of the scripts during our long excursion. We first visit the beautiful seaside city of Durrës, taking photos by the sea and visiting an amphitheatre. At this time the first message from Dominic arrives, telling us that we scored 60/60 in Q1 and 58/60 in Q3! I attempt to start a French conversation with the French team, and Rosie helps with much better success. At 11, the organisers take a brief break and we buy some ice cream and drinks whilst a friendly wolf follows us.

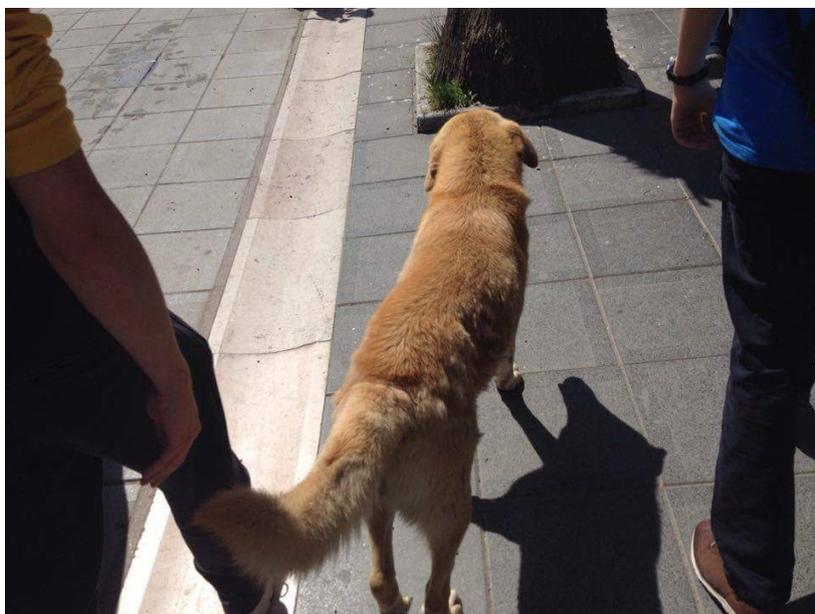


Figure 7: Strange colour for a wolf.

We then visit the mountainous city of Krujë where we see a (fake) bear sitting on a cliff, visit a couple of museums and buy interesting souvenirs, including a tortoise figurine, wooden spoon, felt hat, shot glass and Jacob's partly controversial 'Greater Albania' T-shirt. Dominic subsequently sends two more texts; in Q2, Renzhi and Thomas both scored 10 for their solutions, I lost a mark for an inverted diagram, and Jacob and Rosie each gained a mark for proving the isosceles case. Jamie was awarded two marks for his progress in Q4, and I was given a (possibly spurious) mark for Q4 for mentioning 'taxicab distance'...

During the three hour journey back to the hotel, a Bosnian girl called Neira speaks to us. The Bosnians seem to have a knack for geometry problems, as she tells us that they all solved Q2, but did not do much on the rest. When we return, we find Dominic, Gerry and Jill to go through the scripts with a quick discussion of Q4. Rosie and I carefully go through the details of Thomas' impressive trig bash solution for Q2, and then we all decide to play Irish Snap.

In the lobby, the organisers have made an animated PowerPoint with all the students' marks. As the scores pass by one by one, we eagerly attempt to guess the medal boundaries, and conclude that the UK is 7th in the competition, a notable achievement. Suddenly someone asks us with a feral

politeness to leave the venue, so we have some dinner then watch the eccentric film ‘Man Up’ with Albanian subtitles.

A mellifluous knock is heard on our door. It is Dominic with the medal boundaries! Unfortunately Thomas has lost out on a Silver by one mark, which is a great pity, but nevertheless, we have all done very well, all of us winning medals; two silvers and four bronzes.

Monday 9th May

Today there is another long excursion. Along the way to the Temple of Apollonia some of us attempt 1990 IMO Q3 to not much avail. Neel sends his nice Q4 solution to Renzhi, and we start to look through it. The temple is in ruins, although its front and the stone seats are still partially intact. We also visit a museum with some ancient artefacts, in which we successfully translate some French as a group. We then travel to Berat, a beautiful mountainous city home to the ‘best museum in Albania’. There we cautiously climb on stone walls to capture the best panoramas of the stunning scenery and visit the museum, which entirely consists of original artworks.



Figure 8: The ‘group selfie’ became quite infamous.

At the hotel, the French find us to play a variant of Mafia, ‘Werewolf’, with us. The villagers are massacred; indeed, there is little hope remaining when a werewolf becomes the mayor and both masons are killed in the first few rounds. All of the sudden, there is a knock on the door. One of the Greeks walks into our bathroom to use our shower!

The Closing Ceremony is a formal event with a variety of performances including very loud singing and more dancing, accompanied by sporadic clapping in time. A reflective video portrays an ‘interesting’ photo of Jacob, and then the awarding ceremony begins. Fortunately all of our flags are the right way up, and some countries take spaces in front of us. After the golds are handed out, the whole UK team progress onto the stage once more - but this time we learn our lesson - we leap right onto the front of the stage and stay there, so that we cannot be obscured. A huge number of photos are taken, some also with other countries; some with their consent, some possibly without...

Seeing Sebastian’s university we take photos with him in front of the building. Some Cypriots, whom I had met, suddenly rush over demanding a group selfie. On the way back to the hotel, a huge multitude of songs are played; this greatly intensifies the atmosphere and when we return, everyone greatly looks forward to the promised ‘party’.

This certainly does not disappoint, with an assorted buffet of foods, some more Albanian than others, and many drinks. I continue with my newly created tradition of group selfie taking (what fun is a photo

without everyone in it?) and the music volume gradually escalates in volume until it is noticeably painful to the ears. Of course, this is a prompt to start the dancing. Yes, the dancing! This music transitions swiftly into disco and extremely vigorous dancing ensues. When everyone is almost totally deafened, we finally return to our rooms and Henry, from the French team, joins our game of Mao, which continues very late into the night. Jacob and Renzhi begin a novel ‘duvet fight’, and listening to the serenades of the Greeks chanting ‘Echo, Echo’ in the corridor, eventually we sleep at 2:30am.



Figure 9: All the flags are the correct way up.

Tuesday 10th May

On our last day, Sebastian takes us on a trip to his idyllic hometown Lezhë. There we travel to a pleasantly quiet beach and sit down on a pier to buy drinks. We then have one of the best meals of the entire trip; fish, delicious mussels, ‘kakao’ drinks and much more, and then we decide to go back to the hotel, during which a very turbulent road unexpectedly brings much laughter from Renzhi. Sebastian very kindly gives us each a bag of souvenirs, and we give him a signed postcard in return.

But the excursion is not over yet! At the hotel there is a unanimous decision to walk up the mountain nearby, and after ascending a tall peak easily, we realise that the descent is not as simple. No-one



Figure 10: The beautiful city of Tirana.

wants to fall down into the chasms below, and after much jumping we manage to return to a familiar place, and all is fine. Along the way we see an animal; conjectures are made concerning its identity, including a chicken (I'm sorry!), wolf and possibly a bear. Eventually it is a goat. Great.

We then try to climb a peak with even more goats, but a ferocious wolf suggests otherwise. Indeed, one has goat¹ to be serious about one's safety.

As it is nearing 6:30pm, we return to the hotel. In order to avoid being left behind by the bus, we swiftly retrieve our suitcases, express our thanks to Matilda, one of the key organisers, and set off, with very little room left in the bus. We say our final thanks and goodbyes to Sebastian at the airport, wishing him good luck for his exam on Thursday. Fortunately, no-one is queried in security, and at the gates, we see the Greeks one last time. Nothing will be said about Jacob's *economic* reply when they told us to enjoy our 'bad British weather'...

Having eaten some food and used Zsigmondy's Theorem (yay!) in an N5 problem, we board the flight that is again, very pleasant and despite us arriving in at Gatwick at 11:05 in the night, we hold walking races on the travelators and stairs. After baggage reclaim, Rosie, Thomas and Renzhi travel back to Cambridge with Rosie's father, and Jamie returns with his parents. Jamie has two exams the next day.

But for Dominic, Jacob and myself, the journey does not end here. A taxi is due for us at 11:45. After repeated calls, half an hour later the taxi driver calls to say that he is 'parking his car'. He later tells us that it is his first job today.

And with that, the 2016 Balkan MO was over. We all enjoyed it immensely, and will have fond memories of it for years to come.

¹This, of course, has goat no reference to Neel Nanda's 2014 Balkan MO report...

Acknowledgements and Thanks

I thank my fellow team members, not only for putting up with my enthusiasm for taking group selfies, but also for making this trip as enjoyable as it was. As a team, we thank all the Albanian organisers for their excellent event and 'flexible' time management, and Sebastian, who helped us in so many ways. We thank our schools, for letting us sit the Senior Maths Challenge in the first place. We thank the UKMT, without which this would never have happened. And finally, we all thank Dominic Yeo (Leader), Gerry Leversha (Deputy Leader) and Jill Parker (Observer), not just for looking after us for the duration of the trip, but also for everything else that made the trip such a resounding success.



Appendix 89 - Score Analysis

Code	Name	Q1	Q2	Q3	Q4	Total	Medal
UNK 1	Jamie Bell	10	0	10	2	22	Bronze
UNK 2	Rosie Cates	10	1	10	0	21	Bronze
UNK 3	Jacob Coxon	10	1	9	0	20	Bronze
UNK 4	Michael Ng	10	9	10	1	30	Silver
UNK 5	Thomas Read	10	10	9	0	29	Bronze
UNK 6	Renzhi Zhou	10	10	10	0	30	Silver
Total		60	31	58	3	152	
UNK 7	min	10	0	9	0	19	Bronze
UNK 8	max	10	10	10	2	32	Gold
UNK 0	Unknown	-	-	-	-	-89	-

Four small observations first: ‘Max’ only just achieved a Gold Medal and our average score was 30 (with the appropriate average). The scores for Q2 are in inverse order to our names, and there is a moderate positive correlation between the scores and UNK numbers (SRCC = 0.671).

But the most interesting fact is the striking connection to the number 89. (Anti-numerologists should turn away now.)

Indeed, the fifth degree polynomial representing our team’s scores is:

$$\frac{17x^5}{30} - \frac{79x^4}{8} + \frac{255x^3}{4} - \frac{1493x^2}{8} + \frac{14591x}{60} - 89$$

and so the infamous UNK 0 achieved a score of absolute value 89. Furthermore, the sum of the scores of UNKs 4 to 6 is 89, and the sum of our scores in Q2 and Q3 is $31 + 58 = 89$. Now let S be the number of letters in the full names of Dominic, Gerry, Jill and the UNK team. Then apply the functions in problems 1 and 3 in this year’s competition, and the answer is 89. This year was the 33rd Balkan Maths Olympiad, and $33 - 2 - 0 - 1 - 6 = 24$, and the 24th prime is 89. If you let A = 1, B = 2, ..., Z = 26 as usual, then the first letters of our names add to 89. Furthermore, if you consider UNKs 3, 5 and 6, not only do their names surprisingly add to 356, but 356 is also a multiple of 89. And as if this was not enough, if you multiply by the factorials of the digits in 2016, divide by the factorials of the digits in 33, then add the dates in May we spent in Albania, then incredibly, the answer is 89! Indeed:

$$\frac{2! \times 0! \times 1! \times 6!}{3! \times 3!} + 4 + 5 + 6 + 7 + 8 + 9 + 10 = \boxed{89}$$

■

Thanks to Jamie who helped to come up with some of these, especially the last one!