

The organization of the International Mathematical Olympiad - IMO with particular emphasis on IMO 2013

Maria Losada

Abstract

The International Mathematical Olympiad (IMO) is the largest, oldest and above all the most prestigious scientific olympiad in the world, its standard can only be maintained by a well concerted international collaborative effort. Nevertheless each year it is organized in a different country and each venue lends to the IMO a different cultural flavor part of the important exchange of the diverse international efforts for locally striving for all the benefits mathematical competitions have to offer. The local organization must be clearly intertwined with the core international collaboration processes that happen at each IMO and the need to maintain the standard and prestige imposes on the organizers certain academic and procedural requirements which we discuss both generally and in the particular case of the resources and choices the Colombian Math Olympiad project offered at IMO 2013.

Introduction

Every year in around 100 countries students are offered the chance to participate in a selection process for participation in the IMO. Millions of students from around the world are included in this process - many of which participate in their country's National Mathematical Olympiad - out of which some 600 students are selected to participate in the IMO. When the two accompanying leaders are included, the delegations that travel to the IMO amount to approximately 800 people.

There are larger competitions around the world, most of them handled via correspondence, but this is the largest scientific olympiad and its prestige is very carefully maintained by a group of mathematicians dedicated to the challenges of elementary mathematics that come from all over the world and constitute the International Jury of the IMO. In effect, the two accompanying persons of a delegation are generally part of the team's trainers and their commitment to the IMO is such that they help assemble and run the IMO at all the different venues throughout the world. This quantum creation of the event allows them to concentrate on their own teams during the rest of the year leaving the IMO practically nonexistent for 11 months, its existence during this period depends on the direction of the IMO Advisory board (IMO AB) and the organizing committee of the following IMO.

A scientific olympiad does not handle the amount of people or publicity of sports olympics, and its budget is marginal compared to these, but it includes the costs of the activities, lodging and board, tourism and materials of around one thousand participants and organizers and this entails an amount of money not so easily attained for a scientist. Some of the funding for the

IMO comes from local organizations and government as a recognition of the impact the IMO and Mathematical Olympiads in general have on the country. And lately, due to the rising participation in the IMO, efforts have been made to ask for worldwide donations such as the one given by Google Inc. for 5 years starting in 2011 in the Netherlands, resulting in the creation of the IMO Foundation. Local monies are also needed for the travel expenses of each delegation, meaning that about one third of the cost to hold an IMO is assumed by the participating countries.

The prestige of the IMO is unquestioned and recognized. This year practically all if not all the freshman mathematics students of MIT are former IMO participants. This prestige is jealously kept by the internal process of the IMO: the confidential compilation and selection of challenging original problems, the transparent and careful implementation of the exam, the meticulous and homogeneous grading of each paper to uphold the worth of each medal granted and the consistent handling of information. All these processes will be studied in what follows, in the light of the interaction between the organizing efforts of the local organizing committee and the well-established procedures and components of an IMO, with a particular emphasis on IMO 2013 organized in Colombia in Santa Marta and Barranquilla in the Caribbean region.

Colombia and the IMO

One of the advantages of the change of venue of the IMO throughout its history has been the increased participation of countries in the region of the host or organizing country. This happened in 1981 when the IMO was organized in the USA and it was the first time that Colombia participated, in fact, so did Venezuela, both have been participating ever since.

The national mathematical competition organizers in Colombia had already been part of a latin american community of mathematicians addressing mathematical education regionally. Under this light healthy competition could only help raise standards throughout latin america. So once they took on the challenge of obtaining significant results at the IMO, it is natural that the creation of the Iberoamerican Mathematics Olympiad followed.

The Iberoamerican Mathematics Olympiad (OIM) began in 1985 with 10 countries participating and with strong support from the OEA, the OEI and the Colombian Ministry of Education. Participation in this olympiad grew until all countries in the region participated, this was the case when it returned to Colombia in 2005. At the same time iberoamerican participation in the IMO grew and part of it was definitely due to the confidence and the information obtained at the OIM. The organization of the OIM and later the central american and caribbean mathematical olympiad helped the Colombian olympiad project to gain experience in the organization of an Olympiad. The next step was to organize an IMO which began by the approval of the IMO AB and the International Jury for Colombia to organize the IMO in its Caribbean region in 2013.

General requirements of an IMO

Each IMO has a well established program. The International Jury arrives first to choose the exam. Then the contestants arrive and an inauguration ceremony officially marks the beginning of the olympiad. After that the two important days of exams occur followed by days of grading before the awards ceremony. Then all delegations leave. Throughout there are well-defined

moments apart from the ceremonies when the organizers can offer the visitors a glimpse of their country, in our case the Caribbean region of Colombia.

Generally the IMO lasts 7 to 10 days and its activities are so tightly scheduled that most if not all of the logistical planning is done ahead. All the materials that aid its implementation are provided by the organizers. Everything from the registration process to the printing of name tags is handled by the IMO system (see below) and each year new applications are developed that can further help with the standard preparations for the IMO. Besides this a lot of work is done in design of the logos and materials and communication of the event to enhance its impact and to help fund it.

At the same time as totally logistical preparations are being made such as the choice of venues, materials, guides, transportation, tourism and entertainment, other more academic issues are being taken care of like the invitation of the coordination group and the problem selection committee and the compilation of the short list of problems for the IMO. All the latter will be expanded more below since they are determined by the well-established practices of an IMO.

Not surprisingly fund raising activities come hand in hand with those with academic and international flavours and impact making the IMO interesting to the host country's government and other organizations via the Education and Tourism departments.

In Colombia both sectors were involved and helped with both funding for the olympiad as well as the opportunities to show Colombian culture. In particular a strong contribution to the latter came from the Carnaval de Barranquilla's organization at the opening ceremony. But funding wasn't sufficient to offer a variety of tourist options making the choice of the jury site in the port city of Barranquilla at a reasonable distance between historical Cartagena and Santa Marta, and the student site in Santa Marta at a fine and large tropical beach resort, very significant in this respect.

Above all, everything was planned and prepared to offer the optimal Colombian setting for the international collaboration and standards that are seen each year at an IMO.

IMO website and applications

The IMO website (imo-official.org) was first put into production in Slovenia where it was developed for support of IMO 2006 by a Slovenian math olympiad delegate Matjaz Zeljko who still manages and expands it voluntarily. The necessity of such a site can only be underlined by the extremely impeccable and efficient organization of IMO 2006.

Technology today can help organize any event, but the IMO is a contest that has some very well-defined procedures uprooted and transplanted each year from venue to venue, so automating many of the scheduling procedures (such as registration, arrivals and departures, coordination times, etc.) and the printing of information (such as name tags, exam papers in all the languages coordinated according to seating arrangements, questions and answer sheets,

etc.) makes sense. Luckily the Slovenian organizers undertook the cost of implementing it, for every decision concerning the IMO passes through the IMO jury (or IMO AB) and this particular project would require funding that at the moment the IMO did not manage. Today the IMO Foundation handles a budget for important projects such as this one, that help exhibit the importance of the IMO and therefore the funding of it.

Perhaps one of the most important historical characteristics of the IMO website is the database of results. Still being supplied for the early years, it allows all the former IMO medalists to be displayed with their actual scores and other important statistics. In this sense it is an information site. But supplying the information is a wealth of specifically designed applications that follow the processes of the IMO, for example, an important role is the complete control of registration to the IMO which mirrors the IMO regulations and up to a certain extent aids in upholding them.

Some important changes to the IMO website's applications were made for IMO 2013. Some were just part of the evolution of the applications and the website, but others were required by changes made for Colombian purposes. Of the latter we can include:

- Making available official letters for download on the website. At the same time allowing problem submission to be electronic via upload on a secure site.
- The creation of a problem-selection committee forum to allow the committee to securely view and discuss problems without having to visit the organizing country.
- Scanning of the exam papers with barcode preliminary sheets to efficiently file and make the scans securely available instantly through the website for coordinators (and eventually others); reducing the need to print out the copied exam papers.
- Electronic message boards centrally controlled with information about the day's activities.

All these changes are cost-effective. But the first was a necessity imposed by the inexistence of a reliable postal system in Colombia.

We discuss two of the others in what follows.

Compiling and selecting the IMO problems

The problems used at the IMO must be original, challenging, solvable with elementary mathematical arguments and in fact, use only elementary mathematics in their statement, in order to attempt to measure the young participant's problem-solving ability.

Over the years the problems at the IMO have grown harder and harder. It is unlikely nowadays for a participant to be able to solve most of them without some training. Creating an original problem in elementary mathematics that is challenging enough for the level of training of some of the participants has become a challenge in itself. Recognizing a problem as one used before in so many different National Mathematical Olympiads and all kinds of other competitions throughout the world is a knowledge and memory feat. Only people immersed in the olympiad scene can have the means to keep up with this. In fact, this is one of the important tasks of the International Jury of the IMO which is composed of one delegate of each country called the team *Leader*, to propose and choose the problems for the IMO. In proposing they or the members of their country's olympiad are supposed to have the expertise on how to create a

challenging IMO-level problem. In choosing they collaborate in making sure the problem is acceptable, original and unknown.

There is an ongoing debate as to whether the International Jury is now too large to effectively select the problems for an IMO. Diversity is one of the problems. Every different national team has a different focus as to the expected impact of IMO participation. In some cases, national organizers do not focus on problem-creation which gives them limited expertise on problem-selection. In others, the team leader is not only not part of the problem-creation process but neither of team preparation or selection. Concerns over the security of the exam have enhanced the debate as to whether these leaders should be allowed to see the problems before the exam. The proposal is to reduce the group in charge of problem selection.

Before the process of selection begins, a very important task is to compile the short list of proposed problems for the IMO. These problems are submitted by the official members of each country that are in charge of the process of participation of their team in the IMO. Problems should be kept confidential to preserve the original aspect of the challenge posed to each IMO participant and therefore are submitted in a secure fashion. Ideally each country should submit problems each year but this is never the case. Some people of the IMO community are committed to creating problems or compiling problems to keep the IMO operational and its standards high. In fact, former olympiad participants can sometimes reserve a special problem they find for the IMO. Of all these problems submitted a short list must be compiled. In order to make the selection process efficient, the short list must filter out submissions that are inadequate for the IMO be it because they are known or the arguments used to solve them are known and it is easily recognizable that they can be used, or because the level does not correspond to the level of the IMO.

One of the alternatives of reducing the group in charge of problem selection of the IMO due to lack of expertise of some leaders, is to form a very good committee to compile the short list. This committee, called the *problem selection committee*, must have ample knowledge of existing problems, standard mathematical arguments and in general, each member must be an outstanding problem-solver. This is why throughout the years certain former olympiad participants have become experts at choosing a short list and are invited over and over again to the IMO as such. The first filter of the problems becomes very academic and professional. The second filter, that of the International Jury, further allows for problems used locally to be singled out and discarded.

The problem selection committee in Colombia included some of the very experienced former participants of the IMO who had already been part of a selection committee, its head was a former well-known leader of Colombia with good experience in problem solving. Finally, an equally well-known former olympiad contestant, problem creator and solver from Brazil was asked to be a member of the committee, in part because of the established collaboration between our countries, but mostly to pave the way towards the organization of the IMO in Brazil in 2016.

In general the IMO procedures see the importance of having observers from future host countries attend the IMO to gain experience and this is reflected in the general regulations which state that these observers are financially supported. This is limited to two observers from the following IMO and one from the one after. Colombia with the help of the Argentine Math Olympiad team who hosted the IMO in 2012 expanded the group of observers to prepare for IMO 2013 by requesting that at least 6 Colombians become coordinators in 2012 to gain experience. We will talk more about this later, but here I wish to acknowledge the financial and friendly support of Argentina. To expand the benefits of this practice, South Africa and Brazil were invited to send coordinators to Colombia and in the case of Brazil, one of its Mathematical Olympiad's members was invited as part of the problem selection committee.

The compilation of the short list is a long process. Many problems are submitted and of them a great amount must be rejected. Those that are not must be solved and discussed and then ranked, formatted and printed by the problem selection committee. Since the problems are kept confidential because they are the core of the IMO, the committee generally was asked to meet for many weeks at the host country before the IMO. This meant that its members had to request the time from their jobs to travel to the host country to work on the problems. Generally they returned home before traveling again to attend the IMO. To make this process more efficient a secure forum was requested from the website developer, so at least the initial filter of the inadequate problems could be done at home. To avoid the time and costs of multiple visits to the country the committee was invited to Colombia some weeks before the IMO to finish the discussion, formatting, ranking and printing of the short list. They were concentrated in the small town of Villa de Leyva, several hours by car from Bogota where they had intense working hours producing the short list, and the version with solutions, on time for confidential printing in Bogota. The short lists themselves were carried personally by the IMO organizers. It is not too exaggerated to emphasize the importance of the short list for the IMO. There lies the quality of the IMO, the real challenge to its students and producing it in such a professional manner simplifies the work of the International Jury.

In recent years it has become evident that since the problem selection committee has more time to ponder the problems of the short list, their reflections on the adequacy and purpose of each problem are very helpful when the International Jury is selecting the problems for the IMO. This has led the jury to request their opinion during the problem selection meetings, a practice also put in effect in Colombia. Nevertheless, it is my opinion that reflections from experienced leaders that have just tackled the problems are equally important. Not only because they might recognize problems used locally, but because they give the selection process the expert opinion of what it entails to solve the problems under time constraints.

The last thought provoking remark here is to state that perhaps the solutions to the problems need not be handed out at these jury meetings. This is part of the discussions pertaining the security of the IMO exams. The whole contest crumbles if the students know the problems beforehand, and worse if they know the solutions. The growth of IMO participation and the improvement of technology bring these considerations into the light. In Colombia, by request of the IMO AB president, new solutions to problems were not handed out to the leaders to allow

any cheating to be more recognizable. This meant that discussions around the criteria for assigning points to the solutions (for coordination) were delayed until the exams had actually begun.

Exam implementation

To preserve the prestige of the IMO, the implementation of its exams must ensure that no student is given any advantage over the others. This means that careful procedures of invigilation are put in effect to avoid cheating from others or from items taken to the exam. The sheer number of the participants makes the implementation a logistical challenge. To find a venue that can house 600 students set apart from each other, with no distractions and complete comfort was a challenge in Colombia. In the end, the exams were held in a convention center in four large rooms. This solution wasn't ideal either logistically or financially because the center was not on the student site so it required separate contracting and transportation from the student site to the exam site. Fortunately, it was only 13 minutes away.

Contestants were first screened to enter the foyer so that they did not bring more than the required tools. Invigilators helped control entrance and attendance into rooms and then the actual seating. Each participant can request the exam in many languages so in order to be able to accommodate such a diversity of exam packages, fixed seating must be used. The IMO system is programmed to print out the exam papers in a specific seating order according to the language requests. For this the seating must be established beforehand together with coding of the rooms. This information among other as helpful is printed on the name tags given to each participant, directly from the IMO system. Logistical work like this is part of what organizers must do in advance to prepare for the IMO. At the IMO all of these help the processes to run smoothly, especially for the student who is already nervous when taking the exam. Preparing each exam room with rows of seats containing each exam package took at least half a day.

A special room was reserved for the reception and sending of the questions and answers. During each exam day the participants have the initial 30 minutes of the 4 hours and 30 minutes of the exam to ask questions regarding the problems' formulations. Each question is written on a paper and handled by some of the invigilators so that the jury can read and answer it. The IMO system helps to make this process efficient especially at IMOs like the one in Colombia where the International Jury that responds the questions is accessible only via Internet (or lesser forms of communication). Each question is scanned and recorded and appears on a list at the jury's site so that it can be printed and responded. This can happen only when the system is deployed at each site and the users can communicate via Internet. Once answered and sent the question is put on other lists. For IMO 2013 a special barcode was developed to make the process even more efficient. It almost failed because of hardware problems that occurred at the last minute on the first day. This was perfectly implemented after it was fixed.

The exam venue was also chosen for the scanning of the papers to reduce the handling of the exams. In order to aid the correction process and to avoid cheating from those correcting the

papers, all examinations and a lot of the scratch paper have been photocopied or scanned and printed at every IMO. The Colombian IMO organizers and the IMO system developer agreed to implement a more efficient and amply beneficial form of scanning. The scanning teams, composed mostly of guides that were former IMO contestants for Colombia were trained to handle each solution packet for scanning separately like in other IMOs but also to count the papers submitted and record them on a barcoded header paper that was scanned with each solution. This barcode allowed the system to separate each solution scanned from the next and file it in the file corresponding to the student, day and problem number under a predetermined name. With the correct connectivity and security, this meant that the scanned papers would be available electronically and instantaneously to users of the IMO system. In this case it was for the coordinators (see below).

After scanning all the papers were taken from the exam site in Santa Marta to the purposely confidential International Jury site in Barranquilla on the first day; the second day they were handed to the jury in Santa Marta where they had moved for the remainder of the IMO. But the copies of the scanned papers were not printed nor handled, they could be accessed securely on the Internet. Although the Internet connection in Colombia proved to be adequate it was not ideal, but this problem will slowly remove itself as the world becomes more technologically connected.

Coordination and medals

The just and homogeneous correction or acknowledgement of each participant's contribution to a solution of each problem is another part of the transparent organization of an IMO which contributes to the prestige of the medals awarded. For this a special correction procedure has been created called *coordination*.

In order to efficiently grade or award points to each participant's solutions, the leaders and deputy leaders of each participating country first read each of their contestant's papers and allot a number of points to them according to previously agreed upon criteria. This does not only offer the benefit of distributed work but also helps with the actual reading of the paper which is written in each contestant's language.

A group of select mathematicians capable of distinguishing solutions to each problem of the IMO, or the equivalence between mathematical arguments that contribute towards a solution to these problems, form a group called the *coordinators*. Each coordinator is assigned a problem to work on and there are four different groups of coordinators for each of the six problems of the IMO.

Once the leaders of each country have assigned points to the solutions of each contestant, they must present each solution to a problem to a group of coordinators of the problem with the proposed points in order to agree on the amount of points that must be awarded to the solution or solution attempt. The coordinators are the body of judges that ensure that all contestants are awarded the correct amount of points for their work.

The coordination process is complex and requires a lot of logistical organization. Its existence relieves each country and everyone outside the IMO of any doubt that points may be awarded in a prejudiced or unjust fashion. In this way it preserves the prestige of the IMO and becomes necessary.

Coordinators have a lot of work like anyone else that attends an IMO. They must read the solutions or attempted solutions to one exam problem of all the contestants belonging to a fourth of the participating countries, that is around 150 papers. They must assign points according to criteria which they have helped to make. And then they must meet with the leaders of their assigned countries to agree upon the official scores. Added to this are the procedures they must follow for when they cannot agree with a group of leaders. All this in about two days.

To aid the coordination process the IMO system schedules the meetings and keeps a careful control of their implementation. Official results are also recorded there for further consideration and communication. Coordinators are given copies of the papers so they can work in parallel to the leaders.

In Colombia half of the coordinators were former Colombian participants at the IMO with a distinguished record of helping the Colombian Mathematics Olympiad project, the other half were international experienced coordinators which covered many of the participating countries' languages. They were given access to the IMO system containing all the solutions. If they wanted to print out a specific paper it was up to them. This created a small uproar among experienced coordinators and those Colombian coordinators that had been sent to Argentina for the experience because they had always been handed a copy of each exam paper before. In the end though they realized that the process became easier if they accessed it online since there were less papers to handle and above all to share. Very few papers really needed to be printed. And originals were needed only when scanning was deficient. The new requirement was for computers to access the system. Most coordinators had laptops and tablets, but perhaps they should have been requested in advance or provided by a sponsoring company. On the whole the process turned out to be very efficient.

Once the scores of all contestant's papers have been agreed on the medals are awarded according to the total of points obtained by each contestant. Roughly half the contestants are awarded a medal. The proportion of Gold, Silver and Bronze medals awarded is 1:2:3. This means that at each IMO Gold medals are awarded to about 50 of the most talented contestants of the world.

Mathematical exchange

One of the important functions of the IMO is to allow all participants to exchange important ideas about themselves, their culture and their education. To a great extent the IMO helps countries

share their ideas on competition but more importantly it helps to exchange ideas about mathematics education and practices and to a lesser extent mathematics itself.

This exchange is in fact one of the IMO's goals and thereby is an important basis for allowing every country to assist in the IMO's processes.

Contestants get the very important opportunity of meeting people like themselves, with great talent in solving mathematical problems and in understanding mathematical arguments. Before attending the IMO they already have had a chance to meet their own country's peers and turn the competition to be one of the team into patriotic camaraderie. But once at the IMO they have a chance to meet people like them from all over the world and measure up to international standards in a competition which ends up being against themselves. The friendships created at the IMO many times last a lifetime and turn into professional collaboration. This is a unique chance to meet people like themselves that will in high probability contribute to the academic development of mankind. This contribution to the motivation of these talented students in the study of mathematics and other sciences is perhaps the greatest reason for the IMO to be organized, and not by correspondence.

After the exams students have some free time whilst the papers are being marked. This is an excellent opportunity get to know each other and to show a bit of the host country. It is also a great moment to impulse mathematics. In Colombia interesting academic talks were offered. One by a Colombian talent and former IMO participant and leader and member of the IMO AB, Federico Ardila. And another from a fellow latin american mathematician Harald Helfgott who had just released two papers solving the weak Goldbach conjecture. The Goldbach conjecture has been an open problem for over 250 years, the contribution to the solution of the weak Goldbach conjecture turned its peruvian author into a star for many of the IMO participants, including the contestants.

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I wish to acknowledge both the people who helped the core contest to be a success as well as those that helped us add a Colombian flavor.

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