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Comparisons of the IMO and IOI

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Abstract. There are several International olympiads for secondary school students, but the five which are most widely recognised are those in mathematics, physics, chemistry, biology and informatics, in approximate order of founding. Most of these were originally founded under the auspices of UNESCO. Of these, the discipline most closely related to Informatics is mathematics, and in fact in several countries, for example Australia and Bulgaria (the latter of which can be credited as the founding country of IOI), the two olympiad programs are administered by the same organisation. The purpose of this paper is to compare the two olympiads in some detail, including tasks, topics, evaluation, etc. Despite the close relationship between the disciplines themselves, and the fact that there are similarities in the structure of the olympiads, in fact between all five, such as the medal structure, it is surprising also how different are the evolved traditions of IMO and IOI.

Key words: International Mathematical Olympiad (IMO), International Olympiad in Informatics (IOI), syllabus, task preparation, exam format, problem evaluation.

1. History

Of the five olympiads referred to, mathematics, through the IMO, is the oldest, having started in 1959, when the first IMO was held in Romania. This first IMO was only attended by Eastern Bloc countries, and this stayed the case for a few years until it gradually expanded. The first Western country to enter was Finland in 1965.

The IMO has grown strongly to the point where now more than 100 countries participate annually in most years. Rapid growth happened in 1988 when hosts Australia invited a number of new countries from the Asia Pacific, and in 1997 when hosts Argentina invited most Latin American countries in. The two strongest blocs by language are the Russian-speaking group and the Spanish-speaking group from Latin America.

By contrast the IOI is the equal youngest of the major five olympiads (with biology), having been first held in 1989 in Bulgaria. The IOI has grown to be the second largest, with over 90 countries now participating.

2. Exam Formats

The exam formats of mathematics and informatics are quite different, although the number of tasks is similar, over two days, each day 3 problems for IMO, and for IOI (although in 2009 and 2010 IOI added a fourth problem, designed to be very easy).

An informatics task will normally contain a lot of wording, and usually introduce the student to some new situation. Because IOI problems are solved on a computer, extra space is needed for descriptions say of data format. Informatics problems can be quite long and students need some language skills to comprehend the situations described.

By contrast IMO problem statements can be very short. A problem as short as two lines is possible. Of course for a short question question, if dominated by an equation, language might not be so much of an issue, and a problem can be understood in some cases by non-native speakers. However for most questions students will need to understand the language to understand the question.

Whereas informatics questions are worth 100 points, giving a maximum of 800, allowing for a wide spread of scores, IMO problems are always worth 7 points, enabling a maximum of 42 points. Marking schemes can be quite tight. If a geometry question is answered by a perceived unorthodox method, such as using coordinate geometry or complex numbers, a solution might be given 7 points if correct, but otherwise not be eligible for partial marks. In some questions, not all of the points between 0 and 7 are available.

3. Medal Structure

The most similar feature of all the olympiads, and certainly of the IMO and IOI is the medal structure. In both olympiads the 1:2:3 system applies with the same rules on ties. This does permit some meaning to distributions of medals across olympiads.

4. Privacy

The attitudes of the IMO and IOI are almost diametrically opposed when it comes to publication of results. Although earlier I recall the attitude of the IMO to scores was to emphasise that the IMO was an individual rather than team event, IMO now on its official web site `http://www.imo-official.org/` (see "results") publishes the results of every student question by question, even if they get no points, and they also provide official placings for each country each year. (Some earlier individual results are unknown.) This is accepted and completely non-controversial within the IMO community.

There are two possible ways of providing a premiership for countries. One would be to use every point won by the student (as IMO does), while the other, which I have seen done by Australian colleagues from other science olympiads, is to use a medal count based on something like 3, 2 and 1 points for Gold, Silver and Bronze. The IOI strictly leaves off the record scores of students who do not get medals in the longer term, but astute observers of the new dynamic scoring system could construct unofficial premiership tables while they exist.

5. Topics and Syllabus

The IOI maintains an evolving syllabus document. This is quite detailed and is discussed and evolves dynamically. The question of a syllabus for the IMO has not been seriously raised. The syllabus for the IMO is based on tradition and a question would be considered suitable if it fell into past patterns, although occasional experimentation takes place. For example the "windmill" question of 2011 (easily downloadable from `http://www.imo-official.org/problems.aspx`) composed by Geoff Smith of the UK was certainly in this category.

IMO questions have however been based on this unwritten principle since the beginning, and fall into one of the categories of algebra, combinatorics, geometry and number theory. The method of evaluation will be discussed in more detail below, however of the six problems it has always happened that each gets 1 or 2 problems in the final paper, and on almost all occasions (1997 and 2011 are exceptions) geometry is a topic with 2 problems. There is a strong support for geometry, partly because it is envisaged that training in geometry is more likely to yield scores for the students, and partly it is just seen as an important part of mathematics.

The IMO papers have adopted fairly similar structure over the years. In the last 15 years there has been a much greater tendency, as in the IOI for IMO papers to be graded. This means that the first problem of the day should be highly accessible for most students, the last problem very challenging indeed, while the middle one quite discriminating. I believe there is a similar approach in the IOI, although, sometimes as also in mathematics, the results can be a little different than expected.

Over the years the view of most is that the IMO paper has, especially by this structured grading approach, become much more difficult in recent years. There was one IMO, Hong Kong in 1994, in which members of the USA team all scored the maximum 42 points and the cut-off for a gold Medal almost a perfect score. This has not been repeated although it is not uncommon for strong teams such as China to have all students obtain say at least 38 points and Gold Medals.

I have detected little change in the unofficial IMO "syllabus" over the years, although I do note that it has been a long time since a genuine 3-dimensional Euclidean geometry problem was set.

6. Problem Evaluation

Problem evaluation methods of the various olympiads can vary quite markedly and the comparison between the IMO and IOI is quite sharp. Whereas the preparation of IOI papers is mainly entrusted to host and international scientific committees which operate impartially, a huge amount of the design of the IMO paper is in the hands of the Jury (team leaders, meeting before the students arrive, the Jury being the IMO term for the IOI General Assembly).

However before the IMO gets to this point much of the heavy lifting is done by a problem selection committee formed by the host country. Each country is asked to submit to this committee 3 problems. Of course they do not all do this but many do with the result that in excess of a hundred questions can be submitted to this host committee.

If the host country is a country of strong mathematics traditions, as say Romania was in 1999, the evaluators are from the host countries. But there has been a growing trend in recent years, especially among host countries which are not so strong, for them to bring in well-known strong mathematicians from other countries.

Such mathematicians will live together in the time leading up to IMO for typically a month, working through the submitted problems individually, meeting to compare notes, and eventually toward the end of that time forming a shortlist of say 28 problems, approximately 7 from each of the four categories, to hand over to the jury.

So the Jury (team leaders) arrives about 4 days before the students (who remain with deputy leaders) and spends its own time at a "retreat", a secret location where they are not to communicate with the outside world. This tradition has been in place since the USA hosted the IMO in 1981. This Jury takes the short list (and has the benefit of the presence of the committee who formed the shortlist) and during this retreat it selects the paper and translates it into various languages.

During this time another large group of mathematicians arrives and observes. This is the group known as the coordinators, who decide the final marks of the students. In a strong country the coordinators will all be local. There can be 60 of them. In weaker countries these coordinators will include invited outsiders.

Towards the end of the retreat, the coordinators (a separate team for each of the six problems, each with its own captain) becomes aware of the problem they deal with and determines a draft marking scheme. Finally at the end of the retreat, each captain announces its proposed marking scheme to the Jury, and debate takes place. Sometimes the Jury raises issues which result in change to the marking scheme, but despite the fact there can be rigorous debate, a consensus is achieved.

The leaders remain in retreat until the second day of exams, after which they can communicate with their deputies and the students.

The conclusion of the exams sees all scripts photocopied, the deputy joins the leader, and collectively they go through all the scripts, including rough working, and try extract every mark they can (they might also have further advisors, sometimes known as brains trusts, usually very clever people to help the leader and deputy and who are staying at the IMO as Observers, at the expense of their team organisations).

This is a very demanding time on the leader and support group. They need to read the student papers very thoroughly, including rough working, and extract whatever marks they can see. They then have a meeting with the coordinators, who have already read the duplicate scripts and have formed their own opinions. Mostly they agree readily and sign off on scores, but there are many times they do not and need to adjourn. The coordinators are in the stronger negotiating position as they need to be consistent. They do look at matters which are raised. In the end if the leader will not sign off, the matter can go back to the jury, but this is very rare to reach this point. Probably most IMOs do not have such a situation.

So the contrasts with task preparation and evaluation at the IMO and IOI are quite different. This is mainly because of the nature of the subject, despite the intellectual aspects of the subjects being closely related.

The IOI leaders have almost the same responsibilities as IMO leaders technically in problem creation as they can detect a good reason to reject a problem during the quarantine period, and have done so on rare occasions. But the scientific committees of the IOI do most of the work, which also includes a heavy workload in creating the automatic marking regime, mostly enabling scores to be simply notified to students not too long after the exam is completed.

In conclusion, I also note that one of the main differences is that IOI is marked completely objectively by a computer. There is some subjectivity in the coordination of IMO in that the student is reliant on their leaders and the coordinators to find every bit of their work which might lead to a mark.

7. Recent IMO Issues

The IMO is going through a major debate. It sees two vital issues. The executive of the IMO, known as its Advisory Board (very much the equivalent of IOI's International Committee, but with some powers relating to more matters which would transgress some powers held by IOI's International Scientific Committee) recently brought a proposal to the Jury related to two matters, both of which, despite being independent, lent to the same solution.

There was great concern that in the days of mobile phones that the current problem evaluation and setting regime led to a possibility of cheating which was impossible to police. There was also concern that the cost of holding the retreat was so significant that it was inhibiting many countries from bidding to host IMO.

So the IMOAB, as the Advisory Board is known, proposed to the 2011 Jury in Amsterdam that an independent committee be appointed to set the paper (very similar to the way it is done at the IOI) and basically dispense with the retreat, but possibly leaving a similar quarantine arrangement to the IOI to enable avoiding embarrassing mistakes, like selecting a well-known problem for some students, or one with some newly discovered technical problem.

The IMOAB was almost unanimous, but the proposal was rejected by something like a 60 to 30 margin. So considerable debate will continue. Hosts for the next two IMOs have planned on using the traditional format, with a retreat.

I have been to a number of IMOs and IOIs however I do have some experience of the other three main science olympiads as my colleagues in Australia, who work together with me for government support, have helped me understand some of these other traditions. These other three major olympiads also have variations in the way tasks are prepared and assessed and yield to similar comparisons to those discussed above.

8. Concluding Remarks

I have tried to compare some issues as they apply to IMO and IOI because I feel it is important that there is some cross knowledge across the disciplines. Whether this causes us to change anything is not so important, but it is useful to know how others deal with similar issues.

9. References

The official web site of the IMO, as given above, at

`http://www.imo-official.org/`

is the most comprehensive source of data of IMO. It is administered by Slovenia, has whatever scores are known, all the problems, and provides official placings. It is easy using this site to see how a country has performed over time.

There are several sources of solutions. The most definitive were published on the earlier IMOs by Murray Klamkin. See

Klamkin, M.S. (1986). *International Mathematical Olympiads 1978–1985*. Mathematical Association of America.

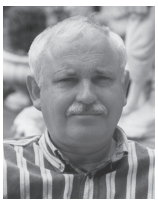
More contemporary collections of problems and solutions can be found on the Art of Problem-Solving site

`http://www.artofproblemsolving.com/Wiki/index.php/IMO_Problems_and_Solutions,_with_authors#2011`.

The 2011 windmill problem referred in the text can be found at

`http://www.artofproblemsolving.com/Wiki/index.php/2011_IMO_Problems/Problem_2`.

A solution is not on this site on 11 March 2012.



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