THE SCIENCE OLYMPIADS

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INTRODUCTION

The Olympiads, like the Olympics, are international competitive events. However, these are related to academics and not sports and the Olympiad events are organized annually and separately for each subject. Teenage students, reputedly the best young minds of their nation, from across the globe, assemble for about ten days at a pre-determined location every year. They are presented with challenging problems of sterling academic standards. In many ways the Olympiads represent a celebration of the best in high school and pre-college science.

The Homi Bhabha Centre for Science Education is the nodal centre for the Olympiads. It organizes the participation in the six Olympiads, namely, Astronomy and Astrophysics, Biology, Chemistry, Junior Science, Mathematics and Physics every year. We have also hosted International Olympiads: Mathematics in 1996, Chemistry in 2001, Astronomy in 2006 and Biology in 2008. Hundreds of students from across the globe gathered in Mumbai for these events. Recently, in December 2013, we hosted the International Junior Science Olympiad in Pune. We will host the International Physics Olympiad in July 2015 in Mumbai.

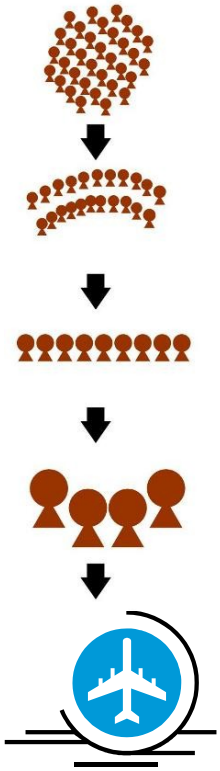
The Olympiads for Physics, Chemistry, Biology, Mathematics and Astronomy & Astrophysics are pitched at the higher secondary school level. There are age limits and conditions that the participating students should not have entered the University system. The Junior Science Olympiad is open to high school students. Based on their performance they are awarded medals: gold, silver, bronze or some honours/special prizes. The science and mathematics Olympiads are conducted in a very democratic and transparent way. All the participating countries have equal rights in the international jury sessions for approving the tests just before they are administered to the students.

India made a late entry into the Olympiads. It started participating in the International Mathematics Olympiad from 1989 whereas the event has its beginnings in Eastern Europe in 1959. The involvement with the Science and Astronomy Olympiads began a decade later: in physics from 1998, in chemistry and astronomy from 1999, in biology from 2000 whereas these events have been organized since 1967, 1968, 1998 and 1990 respectively.

A happy outcome has been that almost every student selected to represent India has come back with a medal from the international event. Our strike rate is almost 100%. Like the sports Olympics, nations are not officially ranked in the Olympiads. However, based on aggregate scores, India is generally among the top ten nations in the Olympiads.

It is imperative also to look at the Olympiads in a critical light. Medals should not be and are not the only goal of this high profile movement. It is a talent search exercise, but has it been a successful talent nurture exercise? How has it impacted on quality science education in the country? How have teachers been harnessed to achieve this? We shall take a critical look at the Olympiads in this article.

THE SELECTION PROCESS



Stage 1: NATIONAL STANDARD EXAMINATIONS (NSEs) held nationwide:
20000-50000 students*
November : Astronomy and Astrophysics, Biology, Chemistry, Junior Science and Physics
December : Mathematics

Stage 2: INDIAN NATIONAL OLYMPIADS (INOs) held nationwide:
300 students*
January-February

Stage 3: ORIENTATION-CUM-SELECTION CAMPS (OCSCs) at HBCSE:
35-40 students*
April - June

Stage 4: PRE-DEPARTURE TRAINING CAMPS (PDTCs) at HBCSE:
4-6 students*
Prior to Departure

Stage 5: INTERNATIONAL OLYMPIADS (IOs):
A team of 4-6 students, Team Leaders and Scientific Observers

**The numbers stated above are approximate and for each subject.*

Figure 1: A Graphical Representation of the Selection Process

The Olympiad selection procedure at HBCSE has now been standardized. Briefly, for science and astronomy Olympiads, it consists of a five stage process. IAPT conducts the first stage with support from emerging teachers associations in Chemistry and Biology, and till 2006 the National Council of Science Museums (NCSM). This stage, called the National Standards Examinations (NSEs), conducted in over 900 centres all over the country, has mainly objective type questions. The second test conducted at about 15 centres, is descriptive with subjective problems of high difficulty level comparable to the international Olympiads. This constitutes the Indian National Physics/ Chemistry/ Biology/ Astronomy/ Junior Science) Olympiads Examinations (INPhO, INChO, INBO, INAO and INJSO), respectively. While the participation in the first test runs into almost a hundred thousand (in the year 2013-14, about 39,000 in Physics, 33,500 in chemistry, 14,000 in biology, 11,600 in astronomy and 24,500 in junior science), approximately the top 300 students in each subject participate in the second test. About thirty five to forty students in each subject are selected from the Indian National Olympiad examinations and are invited for Orientation-Cum-Selection Camps (OCSC) held at HBCSE. The emphasis is on experimental orientation. Students appear for several rigorous theoretical and experimental tests leading to the selection of Indian Teams for the International Olympiads. The selected teams for international Olympiads again go through about two weeks of pre-departure training (IO-PDT) at HBCSE. A *graphical representation of the whole process is given in Figure 1.*

A similar pattern of selection and training is followed by HBCSE in mathematics under the aegis of the National Board of Higher Mathematics. The first stage of the program consists of the Regional Mathematics Olympiad (RMO) where a centrally designed test is conducted at about 24 regional centres in India. The remaining stages are similar to the stages described in the graphic above.

Experimental science is the Achilles heel of the school science education. The Olympiads remain the only tests at the pre-University level which have a strong experimental component. The experiments developed for this purpose are novel and a worthy addition to resources available in the nation. Unlike the Indian Institute of Technology (IIT) entrance exams which is a single stage test, the Olympiad selection is a five stage exercise

with filters and checks and balances. At every stage the student has the right to appeal her evaluation. In the third stage (OCSC) for example the student sits across the table with her evaluators and has the right to argue for higher credit. A related science talent search exam is the Kishore Vaigyanik Prothsahan Yojana (KVPY). This is two stage exam: written and an interview with no experimental component. The Olympiad pattern of selection is worthy of emulation by other examination bodies.

THE INTERNATIONAL EVENT

The International Olympiad is spread over seven to ten days. It is held annually and in a different location every year. It is the obligation of the host country to provide hospitality to the participants. Keeping in mind that the assembled students are likely to be the future scientific leaders of the country the host country showcases its best in terms of its culture, cuisine and science. Our students are accompanied by two delegation leaders. For the past few years an additional observer has accompanied the team. The leaders and the observer are subject experts and provide guidance and counseling to the students. They also act as jury members and partake in deliberations on the competitive tests as well as in policy matters. The students in the Science and Astronomy Olympiads have to take both theoretical as well as experimental tests typically stretching for several long hours. The tests are of exceptionally high quality and designed to test competence and creativity. Unlike many competitive tests in India these are not “speed” tests.

Every effort is made by the organizers to not let political and religious differences interfere with the proceedings and this has been largely successful. There has been a natural evolution in the exams. In the early days the participants were from Eastern Europe and the atmosphere was informal. But with the participation from the Western block and the developing world one now has to draw up detailed grading schemes and adhere to them strictly. The host country also views the students as future science ambassadors of their countries and arranges cultural and excursion programs for the students and leaders during their stay.

The questions for the tests are set by the host country and vetted by the international board consisting of the leaders of all participating countries. The Olympiad Examinations give sufficient weightage for both theory (60%) and experiment (40%) with Astronomy and Astrophysics assigning equal weightage. The latter has a night sky observation component. Strict guidelines are imposed in chemistry to make the experiments safe. There is no experimental component in Mathematics. The unconventional Olympiad problems bring you closer to life and to frontier level research. The experimental component compels you to think with your hands. Both experimental and theoretical questions are interdisciplinary: concepts across diverse areas of the subject have to be understood and integrated in order to suggest a credible solution to the problem. Often only a few questions (say three) are asked and ample time (about 5 hours) is given. The Olympiads probe ability and creativity and not speed. One of our Olympiad books narrates an anecdote which we would like to share with you. “The Stokes theorem which is one of the cornerstones of vector calculus and modern differential geometry was proposed by Sir George G. Stokes as a problem for the Cambridge Smith prize examination in 1854. It is not known if any examinee was able to solve it. But James Clerk Maxwell was one of the examinees and the theorem made a deep impression on him. He went on to use it extensively and laid the foundations of modern electriodynamics.

THE POSITIVE FALLOUT OF THE OLYMPIAD PROGRAMME

The students who are selected for the OCSC are some of the brightest in the nation. They are often the toppers of the board and the professional (engineering and medical) entrance exams. It is worth mentioning that despite our late entry into the Olympiads almost all participating students in the Science and Astronomy Olympiads have won medals at the international Olympiads including the coveted gold medals. Like the sports Olympics, nations are not officially ranked in the Olympiads. However, based on aggregate scores, India is generally among the top ten nations in the Physics, Chemistry, Biology, and Astronomy Olympiads. Table given below encapsulates the medals tally of the Indian teams since 2000. Approximately the top 10% of the participating students are awarded gold medals. 20% of the same are awarded silver medals and the next 30% are awarded bronze medals. In most Olympiads, there is a category called Honorable Mention (HM) for

students who do well but do not qualify for bronze. Sometimes, special awards are given for exceptional solutions to challenging problems and for overall performance among others.

Every Olympiad is an individual event and a key aim is to promote goodwill. Officially, there is no ranking of nations. In the year 2008, India ranked 3rd among 80 nations in International Physics Olympiad. We stood 3rd in International Chemistry Olympiad in the year 2012. India has stood on first and second position several times in the International Olympiad on Astronomy and Astrophysics and in the International Junior Science Olympiad. When India hosted IJSO in 2013, 9 out of 12 students secured Gold medals. It is difficult to quantify the cumulative performance. In general, based on the aggregative scores, India is among the top 10 nations in the Olympiads.

Experimental science is the Achilles heel of science education in India. Recognizing this and its crucial role in the International Olympiads, HBCSE over the years has been involved in developing challenging laboratory tasks and problems in physics, chemistry and biology. A large repertoire of challenging experiments now exists at HBCSE. The experimental expertise has proved useful in a number of ways. The National Initiative on Undergraduate Science (NIUS) launched by HBCSE in 2004, the recently launched national institutes of science education and research, and several undergraduate teaching programs such as the Chennai Mathematical Institute's physics program have benefited from this programme. The theoretical program too has had spin-offs. Olympiad resource persons have been involved in authoring the NCERT textbooks at the higher secondary school level for a decade. Several Olympiad related pedagogical publications in Indian and Foreign Journals (e.g. Resonance, Physics Education and American Journal of Physics) have been authored by Olympiad resources persons.

Since 2004 HBCSE has hosted over 40 resource generation camps in which teachers, scientists and HBCSE personnel gather for a week to prepare lecture notes, devise innovative problems and design new experiments. The camps provide exposure to school and college teachers to state of the art laboratory environment and advanced theoretical problems. At the same time some of India's leading scientists get exposed to the problems of school and college science education. HBCSE personnel routinely visit various parts of the country to give talks and run short camps for students and teachers. A noteworthy aspect is that several of these camps have been held in non-metropolitan and even in rural schools. More than a thousand teachers have attended resource generation and exposure camps, some from Bangladesh, Sri Lanka, Nepal, Thailand and Greece. This is expected to have a positive multiplier effect.

The Olympiads have generated tremendous excitement among the meritorious students in the country. They have triggered the formation of the Indian Association of Chemistry Teachers and a similar association of teachers in biology, along the lines of IAPT leading to grassroots support for science. They have also invigorated the Centre as a whole and strengthened its links with leading scientific institutions in the country.

For completeness, we should like to mention that besides Olympiads, there are two notable programmes of talent search and nurture. These are the National Talent Search Scheme (NTSS) of National Council of Educational Research and Training (NCERT) and the Kishore Vaigyanik Protsahan Yojana (KVPY) of Department of Science and Technology (DST), implemented by the Indian Institute of Science (IISc) – Bangalore. The Olympiad programme of HBCSE complements these programmes but is unique in several ways. Firstly, it focuses on subject specific talent and competence (Physics, Chemistry, Biology, Mathematics and Astronomy); secondly, it involves (in the third stage) rigorous testing and orientation in experimental science – a feature absent in all other talent search and nurture schemes at that level in India; and thirdly, perhaps most importantly, it is not an entrance programme for admission nor a selection scheme for scholarship. The only incentive, as far as the HBCSE is concerned, is to offer students an academic challenge of the highest order suitable at their level, the challenge to go higher and ever higher in terms of subject competence, with a possibility for some to represent India at the international Olympiads and bring glory to our country. The existence of several credible schemes of talent search and nurture (NTSS, KVPY, and Olympiads) is, of course,

a healthy feature of our educational scenario, since they tap different aspects and dimensions of talent in young students.

CRITICAL APPRAISAL

The Olympiads are expected to provide a benchmark for quality education in the country. The second stage INO question papers are of high standard and undergo rigorous scrutiny from some of the best faculty. However little effort has been made to disseminate them. The host institution HBCSE has a small publication division and one can find these papers only in its office in Mumbai. Book stores do not carry them and they are not to be found in state sponsored textbooks such as NCERT. It is well known that there exists a parallel education system in the nation – namely the ubiquitous coaching centers. The more enterprising centers have used the Olympiad questions to train their better students.

The selection procedure is rigorous and the most talented students qualify. It is imperative to nurture them. The Dept of Atomic Energy took a step in this direction in 2004 by launching a scheme called the National Initiative in Undergraduate Science (NIUS). Under this scheme the students who are in the first year of college are invited to attend expository talks and attached to mentors under whom they carry out projects. The students are given a long rope in this matter – they are supported for two or more years so that a worthwhile project is completed. Over 500 undergraduate students have been through NIUS camps. A case in point is Raghu Mahajan the IIT all India rank one (AIR -1) and Olympiad gold medalist (2006) who left the IIT Delhi computer science program midway to pursue a career in physics research at MIT. He has publicly acknowledged the positive influence of the NIUS program in his decision making. Another Olympiad student and NIUS scholar (Akash Kamra) was honoured by his host institution, in this case IIT Kanpur, with a cash award of Rs. 20,000/ for the international publications he authored under NIUS. The research work on quantum teleportation of another NIUS scholar Sreeram Murlidharan from Loyala College, Chennai was singled out for special mention by the renowned journal Nature. He secured the 2009 Erasmus Mundus scholarship for Masters in Europe and is currently at KTH Sweden. A measure of the success of the NIUS program is the presence of undergraduate students at national and international conferences and the scientific publications. The first national conference to showcase undergraduate research was held in IIT- Kanpur March 26-28, 2010 (ICARUS). Over 25% of the talks presented at this conference were by NIUS students. The research output by undergraduate students under NIUS is unprecedented in our nation (http://nius.hbcse.tifr.res.in).

Although a large number of camps for teachers have been held, there has been criticism that these camps are of short duration (3 days) and meaningful training is not imparted. Thus the crucial multiplier effect from which Olympiad resource persons train teachers who then go on to nurture students has not occurred. One reason perhaps is that the nodal institution (HBCSE) has barely a dozen permanent members handling Olympiad programs. Unless this number is increased several fold this multiplier effect will not become a reality.

The Olympiad program labours under several handicaps. For one, the the nodal center (HBCSE) is understaffed. Another major handicap is the parallel education system which at best “teaches to the test”. In this case the test is the lop-sided objective tests which form the basis of entrance to professional courses. The high fees charged by the coaching centers excludes the rural student population. The Olympiad program has made a few fledgling efforts but this is akin to a drop in an ocean. Rural India continues to be (to use Naipual's quote) “an area of darkness”. This is a critical shortcomoing of a program which uses public money.

CONCLUSION

The Olympiad programme has multiple dimensions. In 2004, HBCSE launched National Initiative on Undergraduate Science (NIUS) to encourage UG students to excel in science. Students who pursue a career in Science are encouraged to participate in our NIUS programme. This programme hosts enrichment lectures and supports long-term nurture programme for students enabling them to carry out project work and research. This has led to a large number of publications in international journals by undergraduate students.

Alongwith the six Olympiads conducted by HBCSE, we participate in the Earth Science Olympiad, the Informatics Olympiad, the Astronomy Olympiad and the Asian Physics Olympiad. These too are supported by government agencies, voluntary teacher associations and HBCSE. We caution the students and teachers about private Olympiads, which are not officially recognised by the Government of India. These private Olympiads are expensive to participate in and do not lead to enrollment in International Olympiads.

The Olympiads are not merely competitions. They are a celebration of the very best in Pre-University Science and Mathematics. Although the Olympiads are more than 50 years old, India started participating in them about 2 decades ago. Our vision of the Olympiads is very broad. We view the Olympiad as a vehicle to promote excellence in Science Education at the Pre-University level and, in our own modest way, we try to achieve this by writing books, designing national level tests, holding workshops and camps for teachers and collaborating with voluntary science teacher associations.

Further information on the national Olympiad programme can be obtained from the following website: https://www.iapt.org.in, https://www.indapt.org, and http://www.hbcse.tifr.res.in/olympiads.
You may also write to physics.sutra@gmail.com

About the author: Prof Vijay A Singh was faculty at IIT Kanpur (1984-2004) and Chief Editor of the Bulletin of the Indian Association of Physics Teachers (1997-2000). He has been associated with the Indian Olympiad program since its inception and was the National Coordinator of the Science Olympiads from 2003- 2014 as well as the National Coordinator of the National Initiative on Undergraduate Science, NIUS since its inception in 2004 (2004-2012). He is the President, Indian Association of Physics Teachers.

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3. For a sampling of Olympiad problems see: Vijay A. Singh et al. in Resonance, Vol. 5, 84-90, August 2000; Vol. 7, 68-75, July 2002: Vol. 10, 75-82, April 2005: Vol.. 11, 90-100, August 2006; Vol. 12, 58-66, June 2007; Vol. 13, 475-486, May 2008.

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6. Olympiad Booklet (both English and Bilingual Hindi-English versions available).

Table 2: List of Acronyms

BRNS	–	Board of Research in Nuclear Sciences
DAE	–	Department of Atomic Energy
DST	–	Department of Science and Technology
HBCSE	–	Homi Bhabha Centre for Science Education
IAO	–	International Astronomy Olympiad
IAPT	–	Indian Association of Physics Teachers
IBO	–	International Biology Olympiad
IChO	–	International Chemistry Olympiad
IISc	–	Indian Institute of Science
INAO	–	Indian National Astronomy Olympiad Examination
INBO	–	Indian National Biology Olympiad Examination
INChO	–	Indian National Chemistry Olympiad Examination
INPhO	–	Indian National Physics Olympiad Examination
IO	–	International Olympiad
IOAA	–	International Olympiad in Astronomy and Astrophysics
IPhO	–	International Physics Olympiad
ISRO	–	Indian Space Research Organization
KVPY	–	Kishore Vaigyanik Protsahan Yojana
MHRD	–	Ministry of Human Resource Development
NCERT	–	National Centre for Educational Research and Training
NCSM	–	National Council of Science Museums
NSE	–	National Standard Examinations
NSEA	–	National Standard Examination in Astronomy
NSEB	–	National Standard Examination in Biology
NSEC	–	National Standard Examination in Chemistry
NSEP	–	National Standard Examination in Physics
NTSS	–	National Talent Search Scheme
OCSC	–	Orientation cum Selection Camp
TIFR	–	Tata Institute of Fundamental Research