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Science Olympiad Achievements at the Secondary Level: A Tri-National Comparison of India, China, and Japan

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Abstract:

International Olympiad competitions are very tough and prestigious events like sports Olympics. This study examines the performance of three Asian countries, namely India, China, and Japan, in three international science Olympiads: The International Junior Science Olympiad (IJSO), the International Physics Olympiad (IPhO), and the International Chemistry Olympiad (IChO).In IJSO, India participated since introductory competition and their performance is far better than China. Whereas China started early of their participation in IPhO and IChO and outperforms than India and Japan. In most of the competition years China, remains within top three positions and their contestants placed in the absolute ranker list, but India and Japan never achieved the top most position in the country rank. Despite their late entry, India and Japan have maintained strong performances, staying within the top ten in international rankings. This study uses document analysis and a comparative approach across a few countries to analyse recent data comprehensively. It is evident that Chinese and Japanese schools follow goal-oriented science curriculum and pedagogical approach emphasizing science-teaching learning through hands on activities from the lower classes and consequently their contestants are excellent in practical skill of the international science competitions. Indian school science education may follow this unique feature for the betterment of science learning and this may be helpful for better performance in such prestigious competitions.

Keywords: *International Junior Science Olympiad (IJSO), International Physics Olympiad (IPhO), International Chemistry Olympiad (IChO), Scientific Knowledge, Science Education.*

Introduction:

Physics Olympiads demand a synthesis of mathematical truth (Benacerraf, 1973; Putnam, 1975, 1979; Hempel, 1984; Zheng 1994; Pramanik, 2023, 2024a, 2024b) and scientific knowledge (Kuhn. 1962;Omnès, 2005; Sigurdsson, 2016). The concept of mathematical truth evolves in different directions from fuzzy (Zadeh, 1965) to neutrosophic sense with uncertainty and indeterminacy (Smarandache, 1998, 2013; Broumi, Bakali, Talea, Smarandache, Uluçay, Sahin, Dey, Dhar, Tan, de Oliveira, & Pramanik, 2018; Pramanik, 2020, 2022; Smarandache & Pramanik, 2016, 2018, 2024, 2025). Science Olympiads are one of the most effective ways (Lim,Cheah, & Hor, 2014) to promote science communication among students. Thus, the Olympiad challenges students to navigate the precise boundary where abstract mathematical certainty

(Benacrraf, 1973) meets the testable predictions of the physical world. It pairs students with scientists and educators, which is essential for developing scientific literacy (Nandy &Pramanik, 2025a, 2025b; Ghosh &Pramanik, 2025).

International Olympiads are prestigious competitions just like sports Olympics where different countries participated throughout the world. However, unlike Olympics, Olympiads are held every year in different subjects. Young talented high school students under 20 years of ageare selected and trained for the participation in the international Olympiad competitions.

There are several science Olympiad competitions (Nandy &Pramanik, 2025a)for secondary school students organized internationally, and some well-known and prestigious competitions are International Junior Science Olympiad (IJSO), International Physics Olympiad (IPhO), International Chemistry Olympiad (IChO), International Mathematics Olympiad (IMO) (Pramanik & Guha, 2019; Pramanik, 2019;) and International Biology Olympiad (IBO). Most of these Olympiads have been introduced under the support of UNESCO (Taylor, 2012). The study focuses on performances of Indian, Chinese and Japanese students in the IJSO, IPhO and IChO competitions.

Literature Review:

In 1967, when IPhO was first introduced, several Asian countries like India, China, Singapore, Thailand, Korea and many more were considered as less developed in science and technological potential (Kreminsky, Martyniuk, & Martyniuk, 2021). The success of countries such as China, India, and Singapore in IPhO competitions is the primary focus of this study.

The first International Physics Olympiad (IPhO) was held in 1967, organized by Poland, following the establishment of the International Mathematical Olympiad (IMO) (Pramanik &Guha, 2019; Pramanik, 2019) in 1959. The following year, in 1968, the International Chemistry Olympiad (IChO) (Nandy & Pramanik, 2025a) was launched in former Czechoslovakia. Until 1980, participation in IChO was limited for some countries due to some political conflicts between Czechoslovakia and Russia. After that, most of the developed and developing countries started to participate in IChO and year-by-year number of participating countries increases gradually (Walawalkar, 2005).

India first took part in IMO, IPhO and IChO respectively in the year of 1999, 2000 and 2004. Homi Bhabha Centre for Science Education (HBCSE) and Indian Association of Physics Teachers (IAPT) have jointly taken initiatives for conducting Indian National Olympiads (INO) in mathematics, physics, chemistry and biology. The Indian National Olympiads (INOs) are designed to identify outstanding scientific talent among students and to provide rigorous training at the HBCSE nodal center in preparation for participation in the International Science Olympiads. The first stage of INO (i.e. NSE exams) is solely organised by IAPT whereas the following stages are conducted by HBCSE (a national center of Tata Institute of Fundamental Research (TIFR), Mumbai]) (IAPT, n.d.; Nandy & Pramanik, 2025a).

The IChO is mainly an international tough competition in chemistry for high school students where equal weightage has been given in both the theory and experimental tests. The theoretical test judges the students' in-depth understanding of knowledge in chemistry and the open-ended experimental test generates curiosity in chemistry practical i.e. experimentation which leads to create strong base in the subject and further helpful for pursuing fruitful research in chemistry (Prabhu, 2018).

The Olympiad exams are not only a science competition rather it involves the searching for extraordinary young talents in science as well as nurturing them through proper trainings (Verhoeff, 2011). In addition to the student's quality, there are several factors that are helpful for winning a medal in such a tough international competition by competing with the world's best talents. Some important factors are gifted students, high quality educational system, creating competitive environment through national Olympiads, to channelize student's hardworking ability through proper guidance and trainings (Jovanov, Mihova, Kostadinov, & Stankov, 2018).

Nandy and Pramanik (2025a) found that Singapore and the USA performed very well in IPhO (n.d.)and IChO (n.d.) whereas performances of Indian students are not so good compared to other two countries.

Research Gap:

Although numerous comparative studies on Science Olympiad performances have been conducted, there is a lack of evident research comparing India, China, and Japan.

Motivation: To fill the research gap, we initiate to conduct the comparative study.

Objectives:

Objectives of this study are:

(1) to present the preparation of IJSO, International Physics Olympiad (IPhO) and International Chemistry Olympiad (IChO) of India, China and Japan at secondary level comprehensively.

(2) to compare the performance of the selected three countries in the IJSO.

(3) to compare performances of the selected three countriesin the IPhO and IChO.

Methodology:

General methodology- Qualitative study,

Methodology- Few-country comparison (Lor, 2018),

Comparative approach- Case-oriented studies, Content analysis and Document analysis.

Research materials- Original Govt. documents, Ph.D. thesis, books, edited books, newspapers, magazines, and peer-reviewed journals.

Data collection procedures- Multiple procedures consisting of studying journals (print and online), books, newspapers, and periodicals have been used.

Data analysis- The study applied the document-based analytical approach. To analyse the data historical and sociological strategies wereemployed.

Major findings:

IJSO (IJSO, n.d.a)

The IJSO is an internationally organizing prestigious science competition held every year in the first week of December. There are presently near about fifty member countries participating in the IJSO every year. The role of a country for participating in the IJSO is as an observer or a delegate, or as a host country and most importantly the country must fulfil the IJSO governing statues. The IJSO annual competition aims to develop the awareness of natural science for the young children of fifteen years or less on 31st December of their participating year. A participating country may participate with individual participants or group of participants as a team.

Aims of IJSO:

Major aims and objectives of IJSO (n.d.a) are:

- To develop interest in science subjects among school going students through improving critical thinking, experimentation and solving problems scientifically.
- To identify the student's understanding of science topics as given in the challenging tests.
- To cultivate the scientific attitude and skills among the talented young children and flourishing their extraordinary talents and further expanding and deepening their knowledge from the early age.
- To promote the peace and understanding of global cultures through interactions among the students from various participating countries throughout the world.
- To develop a habit of cooperation and collaboration towards friendly learning atmosphere.
- To provide an ample data for comparing the recent trends and future directions of school science education system (including syllabi) between various participating countries.

Eligibility for participating in IJSO:

School going children must be 15 years or younger in age on 31st December of the IJSO competition year.

Structure and subject matter of the IJSO syllabus:

The International Board of IJSO validates and publishes the new updated syllabus nearly more or less every three years. As in most of the member countries, science is taught as integrated science (physics, chemistry and biology together) for the young students of 15 years or less old, so structure of the IJSO syllabus also highlights in the basic concepts of science instead of taking discipline-based approach. The concept of general science mainly focusses on the solving problems of interdisciplinary science contents. Syllabus of the

IJSO was accepted at the 6th IJSO in Baku, Azerbaijan 2009 and revised by the International Board December 2020 (IJSO,n.d.b)

The syllabus content is derived from:

- The previous IJSO syllabus,
- National curricula for students aged 15 and under in participating countries, and
- Past IJSO problems up to the 5th IJSO (2008).

Modifications were made where appropriate through additions or omissions.

Types of problems given in the IJSO examination:

- Students have to investigate outside science topics besides the ascertained IJSO syllabus for solving the hard problems given in the exam paper with the help of sufficient relevant information supplied in the problem itself.
- In addition to additional theoretical topics students should aware of the various apparatus used in the experiments.
- The additional or outside topic will not cross 10% in any exam paper.
- All the units will be given in SI units.

- The values of natural constants also provided with the problem.

Pattern of the IJSO examination:

Duration and language of the exam: 3 to 4 hours of long duration,questions are set in English language but translation facility of each country's native language is also available.

Type of tests: Three types of tests-MCQs, Theoretical and Practical based tests are held on three separate days.

Part I (MCQ test): It consists of 30 questions where 10 questions from each physics, chemistry and biology are allotted.

Part II: It consists of 40 theoretical questions and 40 practical based questions.

The IJSO syllabus includes mainly three main parts:

1. General science skills,

2. Conceptual knowledge in general science and mathematics, and

3. Laboratory skills

1. General Science skills:

Students are expected to be familiar with also be capable

- To apply and explore various scientific methods, proper use of scientific terms.
- To develop hypotheses.
- To employ accurate scientific methods or experiments to prove the hypotheses.
- To judge the validity of various sources of information, must be aware of the wrong or inaccurate data.
- To represent the data with the help of diagrams, graphs and tables.
- To interpret and analyse data scientifically.

The details of the updated syllabus can be found at IJSO (n.d.b).

Preparation for IJSO in three countries

Preparation for IJSO in India (IAPT-JSO, n.d.)

Indian Programme for Junior Science Olympiad (JSO)

In India, the national-level Science Olympiad examinations are held and coordinated at numerous schools nationwide. The Junior Science Olympiad (JSO) was previously organized jointly by the IAPT and the HBCSE. However, since the 2022–2023 academic year, the entire responsibility has been taken over by IAPT.

The screening for selection of candidates for IJSO and culminating their talents towards the success in IJSO is organized in five comprehensive stages (Fig.1).

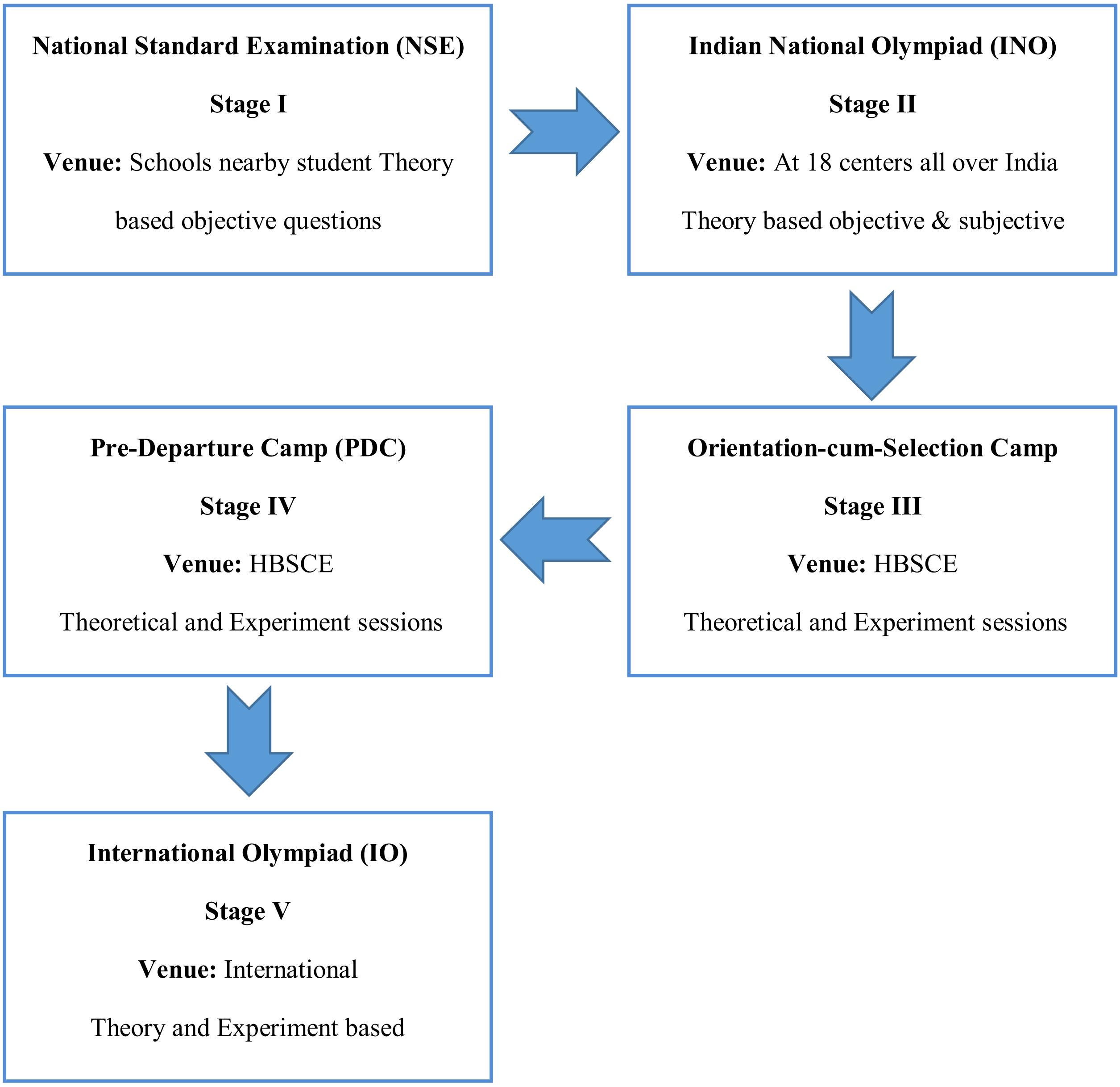

Fig.1: Selection and stage wise preparation of Indian students for IJSO, IPhO and IChO in India (source IAPT, (n.d.); IAPT-JSO,(n.d.))

Eligibility Criteria:

Indian students of 15 years or younger in age studying in class 8, 9 or 10 in the competition year.

Stage 1:

National Standard Examination in Junior Science (NSEJS)

Exam. Centers: 1000 schools all over India.

Syllabus: Class 10th syllabus as mandated by Central Board of Secondary Education (CBSE), although questions are expected to come hard than CBSE 10th board examination.

Question pattern: 60 MCQs from physics, chemistry and biology topics.

Duration and full marks of the exam. : 120 minutes for 216 marks.

Awards and certificate system: Certificates and awards are conferred upon the top research submissions at the center, state, and national levels.

Stage 2:

Indian National Junior Science Olympiad (INJSO)

Test centers: at all the 15 HBCSE venues.

No. of selected students: approximate 300 top performing students in NSEJS qualify for INJSO.

Timing: end of January of every competition year.

Syllabus: same as the stage 1 exam (NSEJS).

Duration and full marks of the exam. : 180 minutes for 180 marks.

Question pattern: full marks 180 is divided into three sections-

Section I (45 marks): 15 MCQs of 3 marks each. There are negative marking scheme for this section.

One mark is deducted for each wrong answer and no marks awarded for unanswered questions.

Section II (45 marks): 9 MCQs of 5marks each. There are no negative marking scheme in this section.

Section III (90 marks): there are 11 subjective questions and students must solve the problems using proper methods.

Stage 3:

Orientation-Cum Selection Camps (OCSCs)

Camp centers: HBCSE centers**.**

No. of selected students: 35 students are selected for this special orientation training.

Timing and duration: OCSCs are held from April to June for 2 to 3 weeks of training.

Purpose of the OCSCs: to foster conceptual foundation with improved problem-solving attitude. Students have to go through various theoretical and practical oriented tests during this training period.

Stage 4:

Pre-Departure Camp (PDC)

Camp-center: HBCSE (TIFR)

No. of selected students: 6 students from OCSCs.

Timing and duration: 2 weeks of training in July of every competition year.

Purpose of training: Selected candidates have to go through rigorous training (both for theory and practical) in science by eminent resource persons from various institutions throughout the country. Special laboratory set up is developed at HBCSE for practical in science.

Stage 5:

Participation in the IJSO

Venue and timing: organized at different countries in December of every competition year.

Teams and mentors: Two teams of 6 students with 3 teachers or mentors.

Teacher's role in National Olympiad programs: A huge number of secondary, higher secondary and undergraduate (college) teachers are engaged in the national Olympiad programs and prepare the contestants accordingly. Teachers have to apply online through HBCSE's website for taking part in the academic and other activities related to the national Olympiad exams. Teachers are invited according to their application in the following camps at HBCSE campus (HBCSE, n.d.).

- Resource Generation Camps (RGCs).
- Exposure camps.

These camps are organized mainly at the second half of the calendar year, through these camps teachers become familiar and oriented towards academic and other activities of Olympiad exams.

Preparation for IJSO in China: For the preparation of IJSO Chinese students have to go through in-depth science concepts, expertise in problem solving skills and successfully take part and qualify in the local and national level science competitions. National level science Olympiad examinations are multi stage process where selected candidates have to take training from coaching institutes or training programs that are helpful for expertizing in IJSO.

Preparation for IJSO in Japan:

Japan did not take part in IJSO until date and hence no such systematic procedure for selecting and preparing students is evident in Japan.

International Physics Olympiad (IPhO) **(*IPhO, n.d.)***

This is one of the very much prestigious science competition for high school students. IPhO is organized every year by ministry of education with association of physical science societies or other institutions of the host country which is also a participating member country.

Eligibilitycriteria:

- A participating contestant must be a general high school or technical school student.
- Students who have passed out their school examination but still their university or college not started in the competition year may also be eligible for the competition.
- A contestant must be less than 20 years of age on 30th June of the competition year.

Language of the IPhO:

Only English language is used in the competition.

Delegation and delegation leaders:

A country's delegation or contestant team is comprised of five eligible students with the supervision of two team leaders or delegation leaders and in some cases one additional observer may also get permission to be included with the team for guiding and counselling the team if needed. The team leaders and observer must be expertise of physics or physics teacher who can solve physics problems efficiently. Team leaders may act as jury members also.

Aims of IPhO:

- The competition aims to find out the excellent competency and unique creativity among students along with their very fast solving capability of physics problems.
- To encourage the future collaboration and to make friendly environments within scientific community.

Patterns of IPhO examination:

The exam consists of two examinations-

I) Theoretical examination: Full marks awarded=30, time duration=5 hours.

Contestants have to solve 3 theoretical problems from four areas of secondary school level physics.

II) Experimental examination: full marks awarded= 20, time duration= 5 hours.

Contestants have to perform one or two problems from the prescribed practical part of the syllabus.

There is a day gap between the theoretical and practical examinations. Contestants are allowed to take drawing instruments or calculator (as determined by the organizing committee) with them for the exam.

Syllabus of IPhO

The main topics of IPhO syllabus are as follows-

- ❖ **Theoretical skills**
  i. General skills related to physics problems.
  ii. Mechanics: Kinematics, statics, dynamics, hydrodynamics and classical mechanics.
  iii. Electromagnetic fields: Basic concept, integral forms of Maxwell's equation, interaction of matter with electric and magnetic fields, circuits.
  iv. Oscillations and Wave: Single oscillator, waves, interference and diffraction, interaction of electromagnetic waves with matter, geometrical optics and photometry, optical devices.
  v. Relativity,
  vi. Quantum Physics: Probability waves and structure of matter.
  vii. Thermodynamics and statistical Physics: Classical thermodynamics, heat transfer and phase transitions.
- ➢ **Experimental skills:** Introduction, safety, measurement techniques and apparatus, accuracy, experimental uncertainty analysis, data analysis.
- ➢ **Mathematical skills**: Algebra, function, geometry and stereometry, vectors, complex numbers, statistics, calculus, approximate and numerical methods.

Awards:

Gold, Silver, Bronze medals and honourable mention (HM) are awarded to total 67% and only medals are awarded to 50% of the contestants. Total 25% of the candidates acquire gold and silver medals, whereas total 8% participants have chances to achieve gold medals only.

International Chemistry Olympiad (IChO) (IChO, n.d.)

IChO is an annual science competition started in 1968. IChO have been organizing every year in the month of July by ministry of education in association with other organising authorities of the host country.

Eligibilitycriteria:

A participant contestant must be a high school student with less than 20 years of age on July, 1^{st} of the competition year.

Medium of IChO:

Questions are provided in English, but unlike IPhO students may take help from their mentors or from registered translators for translating the question into their own language.

Delegation and delegation leaders:

Each country's delegation or contestant team is comprised with four participant students and two mentors. Head mentors can also be the international jury members.

Aims of IChO:

- To promote international contacts in chemistry for creative solutions of chemistry problems.
- To inculcate the collaborating activities and to create friendly environments within scientific societies.

Patterns of IChO examination: The organizer of IChO provides preparatory tasks for the contestants of each participating country in January of every competition year. The contestants may use non-programmable calculator during the examination. IChO examination consists of two parts .

Part one: Practical or experimental examination, total points awarded= 40, time duration= 4-5 hours.

Part two: Theoretical examination, total points awarded= 60, time duration= 4-5 hours.

Practical examination and safety measures:

As in the chemistry practical, students have to do experiments with the help of chemicals they have to maintain the following safety measures.

- Contestant must wear laboratory coat along with eye protector.
- Using poisonous chemicals are not permitted in the laboratory and if needed in special cases appropriate precautions have to take.

Syllabus of IChO

The syllabus includes the topics taught in secondary school levels. It includes:

- Theoretical part

i. Atomic Structure: H-atom, radioactivity,

ii. Chemical Bonding: VSEPR and simple molecular structure, delocalisation and resonance, hybrid orbital theory, molecular orbital theory,

iii. Chemical calculations,

iv. Periodic trend periodic properties,

v. Inorganic chemistry: Study of group 1, 2, 13-18, hydrogen, transition elements, lanthanides and actinides, coordination chemistry including stereochemistry, industrial processes of selected compounds.

vi. Physical chemistry: Gases, thermodynamics (1^{st} law, enthalpy, and 2^{nd} law).

vii. Equilibrium: acid-base, gas phase, solubility, complexometric, phase transitions, multiple pH calculations.

viii. Electrochemistry,

ix. Chemical Kinetics: Rate laws, reaction mechanisms.

x. Organic Chemistry: Basic concepts, reactivity of alkanes, alkenes and alkynes, benzene, halogen compounds, alcohols, aldehydes and ketones, carboxylic acids and their derivatives, amines.

xi. Polymers: Synthetic and natural polymers.

xii. Biomolecules: Carbohydrates, proteins, fats, enzymes, nucleic acids and protein synthesis.

xiii. Spectroscopy: UV, visible, X-ray, IR, NMR, and mass spectrometry.

xiv. Analytical chemistry: Titrations, qualitative analysis, chromatographic methods of separation.

- Practical part: Synthesis of inorganic and organic compounds, identification of inorganic and organic compounds (general principles), determinations of some inorganic and organic compounds (general principles), special measurements and procedures, evaluation of results.

- Mathematical skills: Quadratic equations, trigonometry, logarithms and exponentials, calculus, simultaneous equations.

Awards system:

Among the contestants top 10-12 % of total candidates awarded gold medals and 20-22% receive silver medals and the next 30-32 % awarded bronze medals. The participants with good performances but not awarded by gold, silver or bronze medals are appreciated by giving honourable mentions (HM).

Preparation for IPhO and IChO in India:

HBCSE plays the vital role for conducting Indian science Olympiads of different science subjects run under TIFR, Mumbai. In India, there are mainly five stages (see Fig. 1) for selection and preparing the high school students for IPhO and IChO (Singh & Kumar, 2010).

Stage 1:

NSE in Physics and Chemistry are known as **NSEP** and **NSEC** respectively.

- **Organizing authority:** IAPT
- **Exam centres:** Different schools throughout India.
- **No. of participants (approx.):** 20000-50000.
- **Probable timing of the exam:** in the month of November of previous year for a competition year.
- **Duration of the exam:**For each subject 2 hours' time is allotted
- **Syllabus and exam pattern:** Objective questions are set from theoretical part of the Central Board of Secondary Education (CBSE) syllabus [up to class 12] of physics and chemistry.

Stage 2:

Indian National Physics Olympiad (INPhO) & Indian National Chemistry Olympiad (INChO)

- **Organizing authority:** HBCSE.
- **Exam centres:** HBCSE venues throughout India.
- **No. of participants (approx.):** 300-500.
- **Probable timing of the exam:** January- February of the competition year.
- **Duration of the exam:** for each subject 4 hours.
- **Syllabus and question pattern:** objective and long questions from theory part of the CBSE syllabus (up to class 12) for each subject.

Stage 3:

OCSC in Physics and Chemistry

- **Organizing authority:** HBCSE.
- **Camp centres:** HBCSE.
- **No. of participants:** 35-50.
- **Probable timing of the camp:** April/ May/ June of the competition year.
- **Duration of the camp:** 2 weeks.
- **Purpose of the camp and test type:** camps are organized to improve knowledge foundation and encouraging in problem solving attitudes in physics and chemistry. After completion of the camps, students have to go through theoretical and experimental tests.

Stage 4:

PDC in Physics and Chemistry

- **Organizing authority:** HBCSE.

- **Camp centres:** HBCSE.
- **Total no. of selected participants:**Maximum 5 students for Physics and 4 students for Chemistry are selected from OSCS's for IPhO and IChO respectively.
- **Probable timing of the camp**: July month of the competition year.
- **Duration of the camp:** 2 weeks.
- **Purpose of the camp:** selected candidates have to go through various rigorous trainings in theory and practical in the presence eminent subject experts (mentors). For practical practices special laboratory set up is arranged.

Stage 5:

Participation in IPhO and IChO:

- **Organizing authority:** International Olympiad organization approved host country for a competition year.
- **Competition venue:** International venue in the host country.
- **Total no. of participants:** 100- 400 from all member countries throughout the world.
- **Probable timing:** July- August of the competition year.
- **Duration of the competition:** 10 hours of time duration over 10 days of competition schedule.
- **Competition pattern:** Theoretical and experimental (practical) based tests.

Important rules and regulations of NSEP and NSEC:

- IAPT conducts NSEP whereas NSEC is conducted by IAPT in association with Association of Chemistry Teachers (ACT).
- Mediums of NSEP are English, Hindi and few other Indian languages, whereas only English language is used for NSEC.
- Cut-off marks are not uniform and vary from state to state, as they are determined by individual state quota systems.
- There are Merit Index (MI) and Minimum Admissible Scores (MAS) for NSEP and NSEC which are the criteria of selection for next steps i.e., INPhO and INChO examinations.

Table 1: NSEP, NSEC and NSEJS 2024-2025 exam results (IAPT, n.d.)

Items	NSEP		NSEC		NSEJS Exam. Held on 24.11.2024 & 22.12.2024
	Group A (Class 12) Exam. Held on 24.11.2024 & 22.12.2024	Group B (Class 10 & 11) Exam. Held on 24.11.2024 & 22.12.2024	Group A (Class 12) Exam. Held on 24.11.2024 & 22.12.2024	Group B (Class 10 &11) Exam. Held on 24.11.2024 & 22.12.2024	
Average of top 10 scores (respectively)	166.3 & 188.9	146 & 153.3	178.1 & 177.3	153 & 123.3	152.9 & 126.2
MI (respectively)	133 & 151	116 & 122	142 & 141	122 & 98	122 & 100
MAS (respectively)	83 & 94	73 & 76	89 & 88	76 & 61	76 & 63
Total No. of students above MI	251	201	421	200	310
Total No. of students above MAS	978	421	3167	760	824

Awards and scholarship through NSEP and NSEC: Although the results of NSEP and NSEC are not connected with scholarship but maximum 10 students having top score of every year may get scholarship while takes admission in Bachelor of Science (Physics and Chemistry major).

Centre top 10% students get certificates, state-wise top 1% students get merit certificates and national top 1% students get both merit certificates and book as prizes.

Important criteria and norms for INO (INPhO for physics and INChO for chemistry):

- **MAS** is the 50% score of the average of top 10 scorers and which is the minimum qualifying score for the next stage.
- **MI** is calculated by taking the average percentage of top 10 scorers.
- Participants who obtained 80% or more of the top 10 scorers in the NSEs are allowed for INO in physics and chemistry.
- Separate question and answer booklets are given to the students and they can take the question booklet with them.
- Non-programmable calculator is allowed for INPhO and a periodic table is supplied for INChO.

Reward system: Top 35 students in each subject get gold medal.

OCSC: Top 1% scorer from INOs of each subject are allowed for two weeks camp.

PDC: Every year 5 students for physics and 4 students for chemistry are selected for IPhO and IChO competition respectively and are given special theoretical and practical training during PDC.

Selection and preparation for IPhO and IChO in China:

Preparation for IPhO (CPHOS, n.d.)

Name of the national contest: The Chinese Physics Olympiad (CPhO).

Organizer: China Physics Olympiad Society (CPHOS)

Eligibility: High school students below 20 years of age.

Aims of the exam: To select and to train extraordinary talents for IPhO by testing the understanding of physics topics, problem solving abilities and mathematical skills.

Syllabus: Main topics of CPhO include:

Mechanics, Electromagnetism, Thermodynamics, Optics, Atomic and Nuclear Physics, Relativity.

Pattern of the exam: It comprises of two exams-

i) Round 1 (Theoretical Exam):

Duration: 4-5 hours long.

Question pattern: 5-7 problems are set in the theoretical exam paper.

ii) Round 2 (Experimental Exam): The second round is an experimental exam, where students have to perform physics experiments and record their experimentation results.

Selection Procedure:

a) Provincial Qualifiers: From each provinces top performers are selected for the next round i.e., national round.

b) National Round: The top performers from all the provinces compete in the national level CPhO.

c) Final Selection: The Chinese national physics team is selected from the top most performers (20-30 students) of the national round.

d) Training and International Competitions: The selected team members undergo rigorous training and finally best 5 performers in the training represent China in IPhO**.**

Preparation for IChO (CCS, n.d.; CChO, n.d.):

Name of the exam: China Chemistry Olympiad (CChO).

Organizer: Chinese Chemical Society (CCS).

Introduction of CChO: 1984

Eligibility: High school students below 20 years of age as on 30th June of the competition year.

Process of CChO: It is a multilayer exam-

i) Preliminary round (provincial exam): It consists of 7 to 9 open response questions.

Duration of the exam: 3 hours.

Topics of the preliminary round: Inorganic chemistry, organic chemistry, physical chemistry and analytical chemistry.

Time period of the exam: Late August to early September of the previous year of the competition year.

ii) **Final round (national exam):**It is also known as winter camp. Almost 300-400 or more students are selected every year from the preliminary round and they have to go through rigorous theoretical and practical exams.

Location and time period of the final round: The winter camp is organized by a host city for 5-6 days of the national exam in November-December.

Duration of the exam: Theoretical exam= 4 hours. & practical exam= 3hours.

Other activities: Students take a tour of the host city and perform chemistry-oriented activities as organized by the host and it is similar with the IChO.

iii) **Camp training and final selection of team members**: Nearly 50 top scorers from the final round are selected to attend an intensive two-week training camp, where they undergo rigorous theoretical and practical examinations. From this group, the 4 best performers are chosen to represent China at the IChO, held every July.

Time period the camp training: March of the competition year.

Preparation for IPhO and IChO in Japan:

National Physics Contest Physics Challenge (NPCPC):

Organizer: Japan Physics Olympiad (JPhO) in collaboration with other co-organizers.

Registration / application procedure: Individual students or schools may apply through online mode.

Probable time period of registration: April-May month of previous year of the competition year.

No. of participants (approximately): 1000 to 1500 students every year register for this contest.

Syllabus of the exam: It consists of two parts-

Part I (Theory part): General physics, mechanics, oscillations and waves, electromagnetism, and modern physics.

Part II (Experimental part): how to measure and analyse data, and practical exercises.

There are several steps of challenges and trainings:

A) **First Challenge**: It comprises of two tasks of contest-

I) **Submission of experimental assignment reports:** Students have to submit their experiment assignments of the assigned topic within the registration time period.

II)Theoretical problem contest challenge:

Duration: 90 minutes.

Mode of exam: Online exam (IBT).

Question pattern: MCQ type.

Time period of the challenge: June- July of the previous year of the competition year.

Award system for the 1st challenge contest: i) The contestants with best overall performances in experiments and theoretical challenge receive First Challenge Best Achievement Award also known as Tokyo Electron Prize. ii) The female participants with their best performances receive Tokyo University of science prize.

B) Second challenge (National championships):

Contest type: It is a camp format training and comprises of two contests:

(a) experiment contest (5 hours duration), and

(b) theory contest (5 hours duration).

Time period of the training camp: 3 nights and 4 days camp in August of the previous year.

No. of candidates selected for 2nd challenge: approximately 100 best candidates are selected according to their performance in the 1st challenge.

Award system for the second challenge: 6 contestants receive gold award, 12 contestants receive silver award and 12 contestants receive bronze awards except these some participants got award of excellence, special award.

C) Training for IPhO & Asian Physics Olympiad (APhO): there are mainly three training

i) Kickoff autumn training camp: 3 days camp in September of the previous year.

ii) Correspondence correction training (from September of the previous year to March of the competition year): this training is arranged for the correction of theoretical and experimental data analysis assignments.

iii) Winter camp: 3-night 4 days camp in December of the previous year.

D) Challenge final:

- Spring training camp is organized in March of the competition year for the purpose of selecting Japanese team for IPhO and APhO (n.d.).
- Final selection exam (both theoretical and experimental exam) is held for the selection of 5 candidates for IPhO and 8 candidates for APhO.
- Final selected teams have to go through practicing and correcting previous year exam papers till the IPhO and APhO competitions.

E) Planning for participation in IPhO and APhO: last minute training camp is organized for the finally selected contestants in May and July of every competition year for APhO and IPhO respectively.

Selection and preparation for IChO in Japan (CSJ, n.d.):

Name of the exam: Japanese National Chemistry Olympiad (JNCO)

Organizer of JNCO: The Chemical Society of Japan (CSJ) with the co-operation of Japanese Committee for the International Chemistry Olympiad (JCICHO).

Funding and supporting agencies: Ministry of Education, Culture, Sports, Science and Technology (MEXT) and Ministry of Economy, Trade and Industry (METI).

Eligibility: high school students in Japan (below 20 years of age).

Exam Pattern: it consists of two exams-

1. Theoretical Exam: it has 3 parts-

- Part A: Multiple-choice questions (marks distribution=30-40% of total score)

- Part B: Short-answer type questions (marks distribution=30-40% of total score)

- Part C: long answer or essay type questions (marks distribution=30-40% of total score)

2. Practical Exam: where students conduct chemistry experiments and record their findings and write a detailed report of the experiment.

Total time of practical exam: 4-5 hours

Experimentation time: 3-4 hours for conducting chemistry experiments, collect data, and record their observations.

Report writing time: 30 minutes to 1 hour for writing a detailed report of their experimental procedures, observations, findings, and inferences.

Selection Procedures and training camps:

a) Qualifier Round: The best students from all prefectures compete in this round.

b) National Round: The top students with top scores from the qualifier round participate in the theoretical and practical examination in the national JNCO.

c) Final Selection: The top most scorers (4-6 students) from the national round got selected to form the Japanese National Chemistry Team.

d) Training camp and participation in IChO: The selected team members have to go through rigorous training in theoretical and experimentation sessions and finally represent Japan in IChO.

Time period: The JNCO is usually held in late summer or early fall.

Syllabus: The exam questions cover a wide range of chemistry topics, including organic, inorganic, physical, and analytical chemistry.

Comparative analysis of Olympiad performances:

The present study analyses the data of IJSO, IPhO and IChO competitions.

Comparison of IJSO performances of the selected three countries:

The IJSO since its introduction in 2004, India has participated every year (except 2020 when the competition was cancelled due to covid-19 pandemic) and almost all the contestants from India won a medal every year. China started their IJSO campaign as observer in 2013 and first participated in 2015. The performances comparison (Table 2) between India and China in their common participating years showed that India performed far better than China. Japan took part as an observer country in 2008 but they did not participate till the last competition in 2023.

India achieved 1st absolute rank for 4 times (IJSO competitions in 2014, 2019, 2021 and 2022) with total 6 Gold medals every corresponding year. India got 2nd rank after Chinese Taipei in the most recent IJSO 2023 competition. Data (in Table 2) support for India's consistent excellent results in IJSOs. Japan did not participate in IJSO until 2023 competition.

Table 2: IJSO Performances comparison of India and China in the years when both countries participated (IJSO, n.d.a)

country	2023			2021			2019			2018			2016		
	G	S	B	G	S	B	G	S	B	G	S	B	G	S	B
India	5	1	0	6	0	0	6	0	0	5	1	0	5	1	0
China	0	1	5	1	2	2	0	2	3	1	5	0	2	4	0

Note: **G**= Gold Medal, **S**= Silver Medal, **B**= Bronze Medal

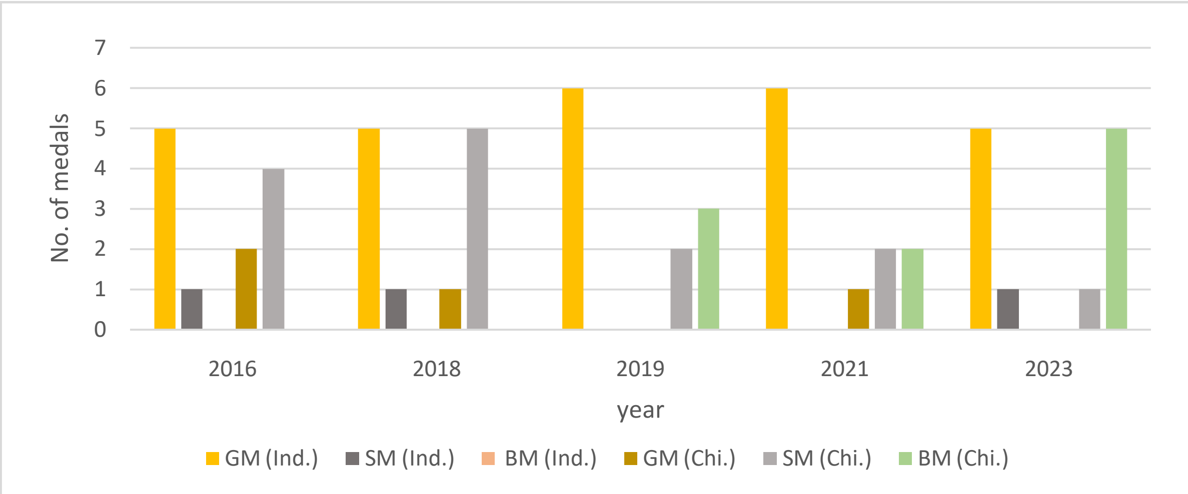

Fig. 2: IJSO MEDAL comparison between India and China

India consistently doing excellent performances in IJSO competitions. India got 1st time 1st rank in 2014 (11th IJSO competition in Argentina) and thereafter four times in the last five IJSO competitions as shown in Table 3. Every time India achieved ranked 1st by grabbing all the 6 gold medals in 2019, 2021, 2022, and 2024 IJSO competitions (see Fig. 3).

Table 3:India's performances in last five IJSO competitions (IJSO, n.d.a)

Competition year (place)	medals awarded			Total Medals awarded	Absolute rank of India
	GM	SM	BM		
2024 (Romania)	6	0	0	6	1st
2023 (Thailand)	5	1	0	6	2nd
2022 (Columbia)	6	0	0	6	1st
2021 (UAE, online)	6	0	0	6	1st
2020	Competition not held due to covid-19 pandemic				
2019 (Qatar)	6	0	0	6	1st

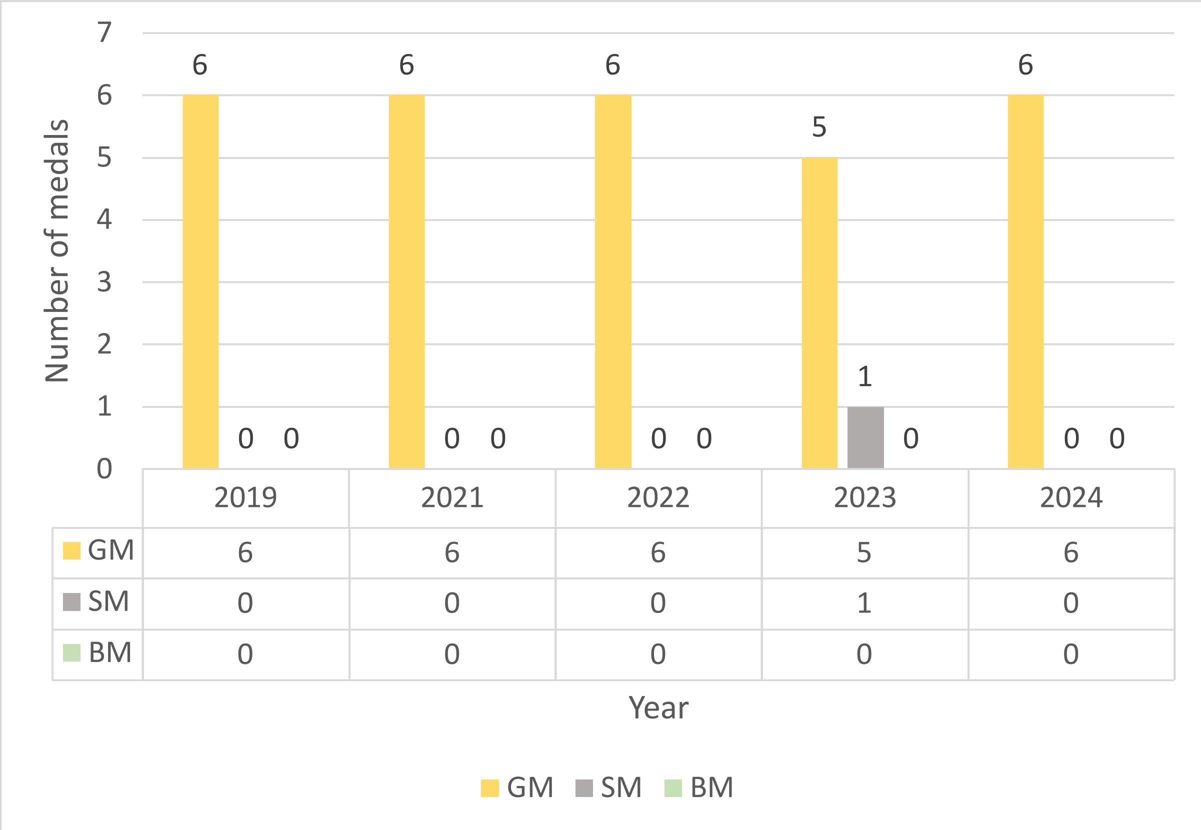

Fig. 3: Number of medals achieved by India in last five IJSO competitions

<u>Comparison of IPhO performances between India, China and Japan</u>

Since its initial participation in the International Physics Olympiad (IPhO) in 1986, China has consistently taken part in almost every edition of the event.India first participated later in 1998 and until the last competition they participated 24 times in total. Japan first participated few years before in 2006 and until the last competition they took part 17 times in total. India and Japan never achieved 1st rank whereas China consistently outperform and achieved 1st position most of the time. Highest rank of India is 2nd and it was achieved three times in the competition years 2001(32nd IPhO, Turkey), 2009 (40th IPhO, Mexico) and in 2018 (49th IPhO, Portugal). The only instance of India for winning all the gold medals in a competition in the year 2018. Japan got highest position 5th in the year 2007 (see Table 4). According to IPhO statue, a contestant team from a country consists of maximum 5 contestants. China grabbed 151 gold medals out of 181 total medals which is far better performances than India and Japan (see Fig. 4).

Table 4: Comparison of IPhO Performances of India, China and Japan between 1967-2024 (Kreminsky, et al., 2021; IPhO, n.d.)

Country	First participation	Observer	Number of participations	GM	SM	BM	HM	Total medals	Highest rank achieved (year)
India	1998	1997	25	51	53	14	7	118	2nd (2001, 2009 and 2018)
China	1986	-	37	151	21	9	2	181	1st (most frequent of their participation years)
Japan	2006	-	17	21	40	20	4	81	5th (2007)

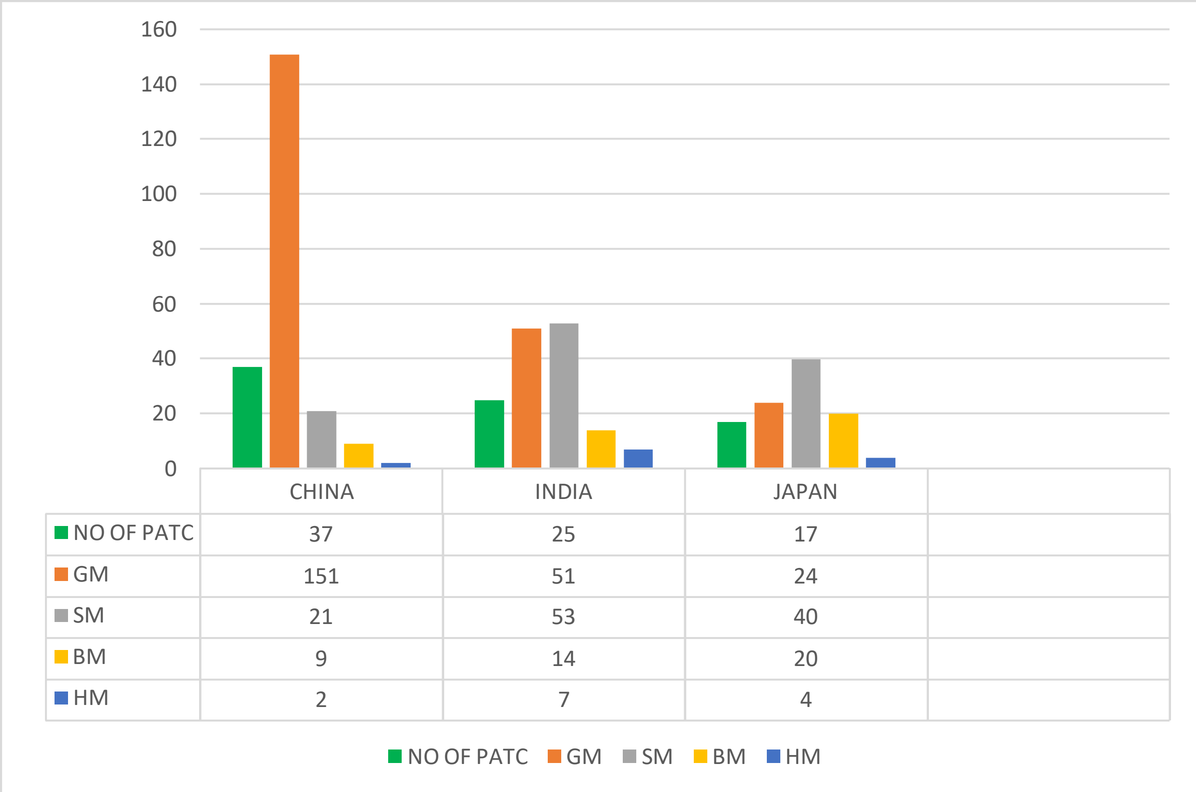

Fig. 4: Comparison of overall performances in IPhO between India, China and Japan

All the three countries hosted IPhO once, China first in 1994 then India in 2015 and very recently Japan in 2023. India organized 46th IPhO in Mumbai with the greatest number of participating countries but country's rank (17th) as a host country is not satisfactory. China organized 25th IPhO in Beijing with only 46 countries and they achieved 1st position as a host country. Whereas Japan organized 53rd IPhO in Tokyo and achieved 7th position as a host country. Number of medals won by the selected host countries with absolute rank in their hosting years are shown in Table 5.

Table 5: Hosting of IPhO by India, China and Japan between 1967-2024 (IPhO, n.d.)

Host country	Number of hosting IPhO	Year and place of hosting	Number of participating countries	Medals awarded to mentioned country				Absolute rank of the host country
				GM	SM	BM	HM	
India	1	2015 (46th, in Mumbai)	83	0	4	1	0	17th
China	1	1994 (25th, in Beijing)	46	4	1	0	0	1st
Japan	1	2023 (53rd, Tokyo)	80	2	3	0	0	7th

Comparison of absolute winners of IPhO:

Several times Chinese contestants become the absolute winner by securing highest score overall in theory and experimental tests. The name, year of competition and score of the absolute winners from China are-

- ✓ Chen Han (1992, score= 44/50)

- ✓ Yang Liang (1994, score= 44.3/50)
- ✓ Yu Haitao (1995, score= 95/100)
- ✓ Liu Yurun (1997, score= 47.5/50
- ✓ Chen Yuao (1998, score= 47.5/50)
- ✓ Lu Ying (2000, score= 43.4/50)
- ✓ Tan Longzhi (2008, score= 44.6/50)
- ✓ Shi Handuo (2009, score= 48.2/50)
- ✓ Yu Yichao (2010, score= 48.65/50)
- ✓ Xiaoyu Xu (2014, score= 41.2/50)
- ✓ Mao Chenkai (2016, score= 48/50)
- ✓ Haoyang Gao (2017, for theory test, score not published)
- ✓ Yang Tianhua (2018, score= 46.80)
- ✓ Xiangkai Sun (2019, score= 43.5/50
- ✓ Guowei Xu (2022, score=43.2/50)
- ✓ Bowen Yu (2023, score= 45.20/50)
- ✓ Zhang Xinru (2024, score= 46.38/50)

In IPhO 2017 competition, Akihiro Watanabe from Japan achieved the absolute winner award in experiment test and this is the only instance for Japan of winning absolute winner award.

Indian contestants never achieved the absolute winner award in their IPhO competitions till 2024.

Comparison of IChO performances between India, China and Japan

Like IPhO, China is also the forerunner of IChO participant among the selected three Asian countries. From 1987 to 2024, Chinese students have accumulated the highest medal count, with 115 gold and 148 total medals across their 37 participations. India ranks second with 100 total medals, followed by Japan with 86 (see Fig. 5). On the other hand both India and Japan executed similar results those are far behind of China. India never achieved 1st rank till 2024 competition whereas Japan achieved 1st rank once in 2022 (see Table 6). Whereas China's splendid performances are reflected with their no. of gold medals and several times 1st rank in the competitions.

Table 6: Comparison of IChO performances of India, China and Japan "between" 1968-2024 (IChO, n.d.)

Country	First participation	Observer	Number of participations	GM	SM	BM	HM	Total medals	Highest rank achieved (year)
India	1999		25 (not participated in 2020)	29	53	18	0	100	2nd (2012)

China	1987		37	115	29	04	0	148	1st (most of their competition years)
Japan	2003	2002	22	25	41	20	2	86	1st (2022)

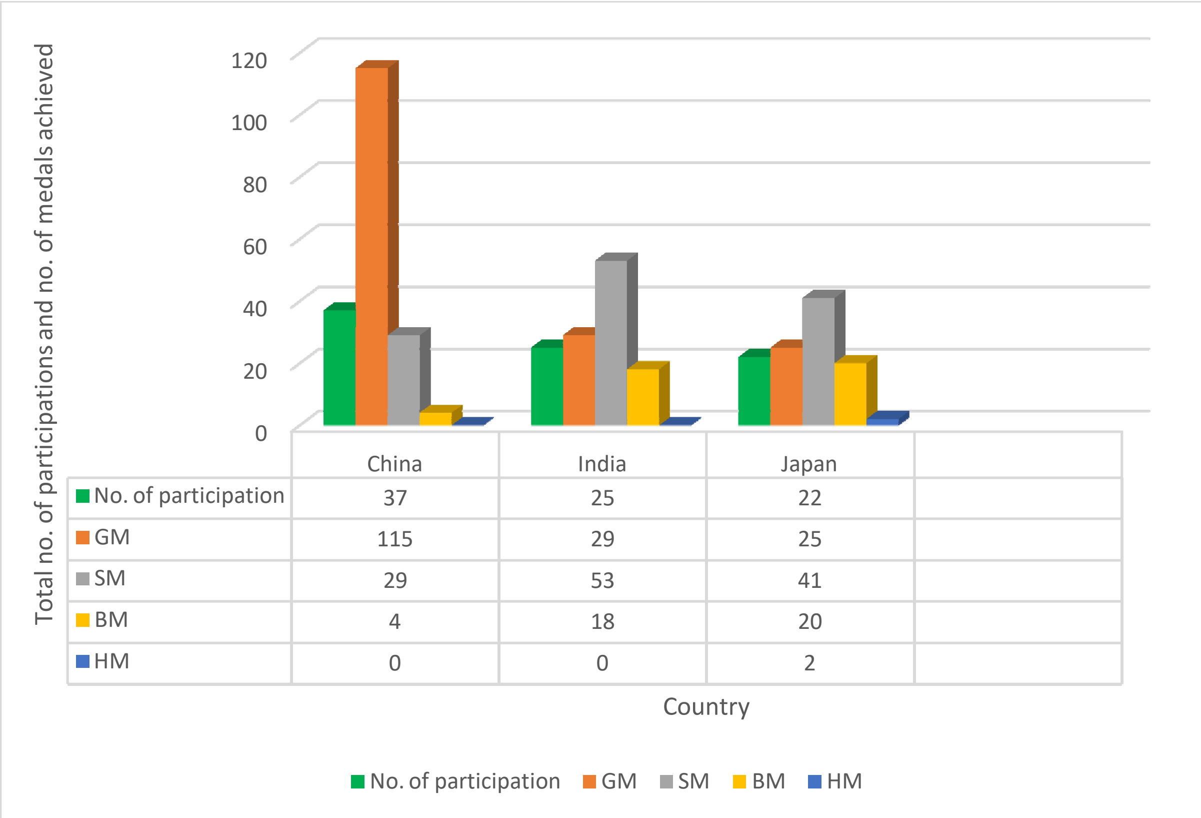

Fig. 5: Comparison of overall performances in IChO between three countries

GIGIndia got the responsibility of organizing IChO only once in 2001 and the Indian contestants won one gold medal out of total 22 gold medals given in this year. Both China and Japan hosted IChO twice, while in both the competitions China bagged all the 4 gold medals each time (according to IChO statue, maximum contestants of each country's team consists of four students). Whereas Japan won 2 gold medals in their first time hosting in 2010 and no gold medals won in their second hosting year in 2021 (Table 7).

The successful hosting of 33rd IChO by India makes a huge impact on Indian chemistry education specifically inclusion of innovative teaching while experimentation in chemistry. Young meritorious Indian talents have been attracted for challenging Olympiad exams as well choose their future career as a researcher in chemistry (Prabhu, 2018).

Table 7: Hosting of IChO by India, China and Japan between 1968-2024 (IChO, n.d.)

Host country	Number of hosting IChO	Year and place of hosting	Number of participating countries	Medals awarded to mentioned country				Total awards given to all countries			
				GM	SM	BM	HM	GM	SM	BM	HM
India	1	2001 (33rd, in Mumbai)	54	1	3	0	0	22	46	63	15

China	2	1995 (27th, in Beijing)	42	4	0	0	0	16	27	40	0
		2022 (54th, in Tianjin, online mode)	84	4	0	0	0	36	71	103	23
Japan	2	2010 (42nd in Tokyo)	68	2	2	0	0	32	58	86	9
		2021 (53rd in Osaka, online mode)	79	0	3	1	0	33	67	94	24

Analysis and discussion:

From the analysis of past IJSO results, it is evident that India outperformed China and this may be due to following reasons-

- Integrated composite and up to date science curriculum at the upper primary (class 6-8) and secondary section (Nandy & Pramanik, 2024; Ghosh & Pramanik, 2024).
- Consistent encouragement and financial support from three vital ministries viz. Department of Atomic Energy (DAE), Department of Science and Technology (DST) and the Ministry of Human Resource Development (MHRD) for Olympiad preparation and related activities.
- Proper way of nurturing the young meritorious students through various orientation camps and comprehensive experimental trainings.
- IAPT's selfless effort for organizing a very standardized international Olympiad oriented NSE exams in science subjects.
- HBCSE (TIFR) as a nodal centre for organizes laboratory trainings with the help of special experimental set up.
- HBCSE also play a vital role for preparing expertized mentors through various orientation programs throughout the year.

The past IPhO and IChO performances of China are phenomenal and remained as top rank country most of the times. There may be some supporting scenario of science education in China as following-

- Learning environment in Chinese high schools are highly competitive as well as Chinese parents are very serious about the success in their children in school and competitive exams.
- China's subject specific curriculum start at the start of their upper secondary level i.e., at the class 10 and hence the students become aware and conscious about the IPhO and IChO very early.
- The high school science curriculum is highly internationalized and the knowledge gap between lower secondary and upper secondary curriculum is not significant.
- Government has enormous financial support for preparing contestants with the help of modern instruments and costly laboratory set up.
- Long time duration of experimental practical training in physics and chemistry aligned with the IPhO and IChO experiment tests.

India's performances in IPhO and IChO competitions are good and consistent (among top 10 ranking countries) over the years (Kreminsky et al., 2021) and this may be due to following reasons-

- Global competitive science curriculum at the senior secondary level.
- Students looking for prestigious professional career in engineering, medical sciences, computer sciences have to crack the national level tough examinations like IIT-JEE, NEET and others. While preparing for those exams students practices various complex problems out of the secondary syllabus, those become helpful for solving conceptual Olympiad problems.
- Government's financial support.
- IAPT and HBCSE's continuous effort to select gifted talents in science and providing proper guidance and training makes the contestants confident about Olympiad exams.

Japan started its Olympiad journey later than India, but its performances have been equally impressive, establishing it as a top-performing country in both the IPhO and IChO competitions. This reflects Japan's science education system as-

- Richness and up to date STEM based science curriculum at the secondary level.
- PhO and CSJ's continuous effort for selecting and nurturing the students aiming for participating in IPhO and IChO competitions.
- Government's support and various initiatives for the promotion of science education in Japan.

Conclusions

China being the second highest populated country after India in the world (Worldometer, 2025) have the greatest number of high school students and they have achieved magnificent performances in international science Olympiad competitions like IPhO and IChO competitions. But China's performances in IJSO is not satisfactory and this may be due to their systematic student preparation for IJSO is not evident like IPhO and IChO. China's advanced globally rich science syllabus, competitive mindset, their hard work, and most importantly opportunities of science teaching learning through hands on experiments from lower levels. India's performances with respect to China is not satisfactory in IPhO and IChO competitions, although Indian students always do excellent performances in IJSO than China. Some of the fruitful actions may be helpful for better performances of India in IPhO and IChO competitions-

- The knowledge gap between secondary and senior secondary science should be reduced and as a result students can cope up with the huge senior secondary science syllabus.
- In Indian science, the practical examination starts mainly from class 11, if science teaching carried out with hands on practical experiments from class 9 or even from the lower classes meritorious students will become more interested and learn physics and chemistry joyfully then this will help them for experiment test in international competitions.
- At senior secondary level (classes 11 & 12) students have to complete huge theoretical syllabus (more weightage) and as a result experimental part(less weightage) may be neglected. So, there must be a balance between theory and experiment part and hence it will be beneficial for competing in international science Olympiad exams.
- There are very rare possibilities of practicing difficult problems of science at the secondary level (class 9 & 10), so there should be All India Junior Science and Mathematics Olympiad exam. This

may help students to be acquainted with the international science Olympiads and may also improve the competitive Olympiad culture throughout the country.

- Due to language problem meritorious students from different state boards are lagging in taking part in national science Olympiad exams and hence these exams confined to limited gifted students. Any steps should be taken to extend the opportunity to take part for most of the Indian youth talents.

- Time period should be longer for practical training of different stages of science Olympiad preparation.

- Training centers with modern instruments for experimentation should be increased.

- National Olympiad winners should get more reward like advantage for taking direct admission in higher education institutions of their concerned subjects (like China and Japan).

- Very recently, IITM launched a program namely, 'Science Olympiad Excellence' (ScOpE), in which the students with excellent performances in national and international Olympiad examinations will get the golden opportunity to take direct admissions into IITM without JEE (Advanced) rank starting from 2025-2026 session. Admission to various academic and skill-based disciplines will be offered to students based on their Olympiad achievements" (IITM, March 10, 2025). Such type of more initiatives should have taken by the prestigious higher education institutions offering higher degrees in Science and Technology.

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