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A Systemic Comparison of Secondary-Level Science Olympiad Programs in India, Singapore, and the USA

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Abstract:

The study is about the performances of India, Singapore, and the USA in Science Olympiads. Here the Science Olympiads are delimited to the International Physics Olympiad (IPhO) and International Chemistry Olympiad (IChO). The preparation of three countries from class 6 to class 12 for IPhO and IChO is depicted here. The study shows the comparison of their performances in those international events. The study reflects the preparation of India and its marvellous performance among the three countries in the International Junior Science Olympiad (IJSO). The study employed the current document-based analytical approach in the few-country comparison method. The performances of the USA in IPhO and IChO are outstanding. Despite, being a very small country, Singapore also performs very well. Though India started late participating, it wonders all with its mesmerising performances in those events. A proper goal-oriented science curriculum along with vigorous laboratory practice is necessary for India's better performance.

Keywords: *International Physics Olympiad, International Chemistry Olympiad, International Junior Science Olympiad, Level of Performance, Science Education.*

Introduction:

According to Kuhn (1962, 1976), scientific knowledge is not a steady, cumulative progression toward objective truth, but rather a dynamic process shaped by paradigms.According Kuhn (1976), mathematics is deeply embedded in the practice of physical science. It refers to both a tool for articulating theories and a product of the paradigm in which scientists operate. Kuhn does not treat mathematics as an independent, timeless truth. Many researchers presented mathematical truth (Benacerraf, 1973,1974; Putnam, 1975,1979; Hempel, 1984; Zheng 1994, Pramanik, 2023,2024) in many directions including uncertainty with indeterminacy and falsity in neutrosophic sense (Smarandache,1998, 2013; Pramanik, 2020, 2022, Smarandache & Pramanik, 2025) to facilitate scientific enquiry.To make a successful science communication, Science Olympiads are most important weapons (Lim et al., 2014). It correlates scientists and educators with students. This is an important corridor for higher level of scientific literacy.

Walawalkar (2005) noted that 'influx' of good merits into higher studies specially in basic science subjects diminished gradually. Necessity of applied science over basic science was reflected through the trends in job market. In India, students have intended more to study either in Medicine and Engineering, or in Business Management and Information Technology. It has become tough for the science teacher to entice their students in basic science. Therefore, Science Olympiad is an emerging issue in India. Science Olympiad is one of the medium through which the natural curiosity and young talent was nurtured and channelled from pre-university level to bright scientific research based career. Singapore and the USA are two countries consistently well performing in science Olympiads. The former, with very less population, and the latter, with third highest population in the world, both manage to fit themselves in top merit list of various Science Olympiads. Whereas India with highest population in the world (Worldometer, 2025) has yet to achieve that position. But, in International Junior Science Olympiad (IJSO), India has performed extraordinarily well.

Here the researchers get interests in studyingPerformances in Science Olympiads of India, Singapore and the USA at secondary level comparatively.

Literature Review

To make the science subject more attractive and application oriented various attempts like- Science Olympiad has been observed. International Science Olympiad first started in Physics then followed by Chemistry, Biology and recently in Astronomy (Walawalkar, 2005). General rules for participation in those competitions as mentioned by the author are-

- Each country participating in the Olympiads has to send a team of 4 to 6 pre-university students of allied discipline,
- Before getting the permission from the organizing committee to participate to the international Olympiad, the interested country has to send observer for two consecutive years.
- Unlike sports Olympics, here the country has achieved medals on behalf of its representatives.

First International Physics Olympiad (IPhO) was organized in 1967 in Warsaw (Poland) whereas International Chemistry Olympiad (IChO) was initiated in former Czechoslovakia in 1968. From 1969 to 1980 participation in prestigious IChO was restrictive due to some political disturbances between Czechoslovakia and Russia. After that IChO became open to all countries. India started participating from 29th IPhO and 31st IChO from 1998 in Iceland and 1999 in Thailand respectively. In India, Indian Association of Physics Teachers(IAPT) complete the first stage of IPhO and IChO, whereas the succeeding stages are controlled and organized mainly by Homi Bhabha Centre for Science Education (HBCSC) with the help of Tata Institute of Fundamental Research (TIFR).In 2004, India was one country with another six countries (USA, China, Taiwan, Korea, Russia and Ukraine) that perform extraordinary well acquiring medals for all the participants in all 5 science subjects including Mathematics(Walawalkar, 2005).

The year 2007 was significantly glorious for India when the country ranked 6thin IPhO among 70 nations and 8thin IChO among 68 nations along with international Olympiad ranking in other science subjects too (Singh & Kumar, 2010).

Singapore has a glorious result in Olympiad exams of science subjects through three decades. It is mainly due to five factors (Lim et al., 2014)-

i. Powerful impact of Science as well as Mathematics learning in various schools, colleges, universities with bright future in science and technology,

ii. Making curricula of Science and Mathematics more practical, competitive and global maintaining international benchmarking (Nandy & Pramanik, 2024),

iii. Encouraging students and making them prepared for those competition on Government's (Govt.) initiatives,

iv. The positive involvement of teachers, universities and various academies for mentoring the participants,

v. Strong partnerships between various scientific societies in the natural sciences which makes it easier to identify top talents in those subjects and to train them properly up to international level.

In 2011, Singapore has achieved 5 gold medals by securing joint 1st position in 42nd IPhO, Bangkok (Thailand) out of 82 countries/ territories. (NUS, n.d.a)

In 2023, Singapore has occupied joint 1st position out of 89 countries/ territories with its marvellous achievements in 55th IChO, Zurich (Switzerland). It happens for the 1st time since after participating in IChO from 1988. In the same year country has ranked 15th out of 80 countries/ territories in 53rd IPhO, Tokyo, Japan. (MOE, 2023)

Eisenkraft and Kirkpatrick (1992) showed that the journey of IPhO in the USA started from 1985 when American Association of Physics Teachers (AAPT) showed interest in the said event and they made convinced the Governing board of American Institute of Physics (AIP). In the first stage, 20 students with high academic excellence were selected very quickly to b U. S. Physics Team and brought to the University of Maryland which is at College Park due to a training session of 10 days. Among them 5 members are selected as final U. S. Physics Team representative and sent finally to London directly. Their extraordinary performance with three bronze medals and one HM(HM) surprised not only the U. S. Physics Community but also the rest of the world. In 1987 the competition grew up to a quite large level when 125 students from 25 countries participated. The U. S. team alone were able to achieve 3 bronze medals and an HM while 3 gold, 10 silver and 27 bronze were provided in all. In 1988, the U. S. team improved themselves to acquire 3 silver and 1 HM. After 1989, Warsaw (Poland), U. S. Physics team members and their coaches got an opportunity to meet with President Bush in the Oval Office over an invitation. This was mainly due to spectacular performance of Steve Gubser being top scorer of the competition along with another 2 bronze medals and 1 HM of other team members. U. S. team showed also remarkable performances in 1990 and 1991with their marvellous team members.

Since 1984, the USA has participated in IChO and American Chemical Society (ACS) has sponsored U.S. National Chemistry Olympiad which is a competition in Chemistry for high school students. In 2017, in 49th IChO, Thailand, the country has made history by securing 1st position and winning 4 gold medals. (ACS, n.d.)

Kreminsky et al. (2021) explained in their studies that how the achievement and performance in International Physics Olympiad was related to the planned attention and its intellectual improvisation of physical as well as mathematical education on the youth of the respective countries. The authors pointed out that mainly the Asian countries like, Singapore, India, Vietnam, Thailand along with Russia and the USA performed consistently well and they maintained stability in their performances. They also found that this success and achievement depended on three points mainly-

- Presence of adequate able performers,
- Proper motivation,

- Appropriate ability to execute the plan properly.

The necessity of stable leaders was also discussed here.

Originality and Research Gap

No comparative study has been found to date about the performances in Science Olympiads of India, Singapore and the USA at secondary level in a comparative manner. The study has filled that gap.

Delimitation of the study

Though there are actually four international Olympiads organised in science subjects (like, in Physics, Chemistry, Biology and Astronomy), thisstudy has been focused on International Physics Olympiad, International Chemistry Olympiad along with International Junior Science Olympiad.

Objectives

Objectives of this study are:

(1) to study the preparationofInternational Physics Olympiad and International Chemistry Olympiad of India, Singapore and the USA at secondary level with contemporary changes.

(2) to study and compare the performances in International Junior Science Olympiadof the three countries.

(3) to compare the performances in International Physics Olympiad and International Chemistry Olympiad of the three countries.

Methodology

General methodology- Qualitative study,

Methodology- Few-country comparison,

Comparative method- Case-oriented studies, Document analysis, Content analysis

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

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

Data analysis- The study has employed the current document-based analytical approach. To analyse the collected data historical and sociological strategies have been adopted.

Major findings

International Junior Science Olympiad (IJSO) (IJSO, n.d.)

IJSO is a totally annual educational event to establish the promotion of Natural Science in young people through the means of individual as well as team competition.

Aims and objectives

- To nurture students in scientific endeavour so that their talents can be flourished from their early age,
- To identify and promote the talents and reward it for its excellence in Natural Sciences,
- To encourage students creating friendship and global relationship,
- To encourage making scientific collaboration in future,
- To make an opportunity to compare the curriculum and trends in science education for participating countries.

Age criteria

Applicable to students who are less than 16 years on 31st December of the participating year.

Syllabus

The syllabus of IJSO-

- depends on basic general science,
- is not divided in Biology, Physics and Chemistry,
- encourages interdisciplinary conceptual problems.gg

Exam pattern

a) **Exam duration-** 3-4 hours

b) **Question pattern-** Both theoretical and practical based questions are given.

Part 1- 30 MCQ, (10 questions each from Physics, Chemistry and Biology)

Part 2-40 theory based and 40 practical based questions are given.

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

Junior Science Olympiad Programme in India (JSO)

Previously IAPT and HBCSE were both organizing National JSO in India. But, from 2022-23, the whole responsibility was taken by IAPT alone.

Eligible candidate

Students of class 8, 9, 10 whose age are under 15 years are eligible.

Steps of selection

Step 1:

National Standard Exam in Junior Science (NSEJS)

- Centre- Organized over almost 1000 centers over the country
- Duration- 120 mins
- Syllabus- Science syllabus of class 10 followed in Central Board
- Question pattern- 60 MCQ of 216 marks in Physics, Chemistry, Biology
- Certificates and Awards- Provided to Centre top, State top and National top students

Step 2:

Indian National Junior Science Olympiad (INJSO)

- Centre- Organized at 15 HBCSE centers
- Duration- 180 mins
- Syllabus- Same as NSEJS
- Question pattern- Total 180 marks
    - Section- I- 45 marks- 15 single correct MCQ each having 3 marks with (-1) negative marking
    - Section- II- 45 marks- 9 multiple correct MCQ each having 5 marks with no negative marking
    - Section III- 90 marks- 11 descriptive questions where solving methods are given more importance than final answer.

Step 3:

OCSC for IJSO

- Organized at HBCSE (TIFR)
- Duration- 2-3 weeks
- Top 35 (about) students are given training.
- 2 teams of 6 students from OCSC are chosen to represent IJSO.

Step 4:

PDTC for IJSO

- Organized at HBCSE (TIFR)
- Duration- 2 weeks
- 2 teams of 6 students from OCSC involve trainings in theories and experiments.

Step 5:

IJSO

Two teams accompanied by 3 teachers are to represent country at IJSO held in December.

IPhO(IPhO, n.d.)

The competition is organized by MOE and associated Physical societies or other institutions of host country. This is the honour and most prestigious for the host country to organize IPhO.

Age criteria

Student should not exceed age of 20 years on 30th June of the year of competition. 5 students of General/ Technical secondary school can participate.

Language

Only English is used.

Leaders and observers

IPhO team is assisted by 2 team leaders and sometimes 1 additional observer who not only give subject expertise but also guide and counsel the team whenever needed. They may be jury members also.

Exam pattern

The test intends to find out competence and creativity in students, not speed only. Exam consists of two parts-

- Theoretical test- 3 problems (maximum 60 points) have to be solved in 5-hours duration.
- Experimental test- 1 or 2 problems (maximum 40 points) have to carried out in 5-hours duration.

There exists 1-day gap between the above two tests. Drawing instruments along with approved calculator are allowed for exam.

Syllabus of IPhO

The theoretical part covers at least 4 areas of Physics taught at secondary level in school. Students should also learn to solve the aligned Mathematical problems too. The syllabus includes-

- Theoretical skills
    i. General Physics,
    ii. Mechanics,
    iii. Electromagnetic fields,
    iv. Oscillations and Wave,
    v. Relativity,
    vi. Quantum Physics,

vii. Thermodynamics and statistical Physics

- Experimental skills
- Mathematical skills

Algebra,Function,Geometry and Stereometry,Vectors,Complex numbers,Statistics, Calculus,Approximate and numerical methods.

Awards

Gold, Silver, Bronze medals and HMare 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 are able to achieve Gold medals only.

IChO (IChO, n.d.)

Every year in July,IChO is embodied with the help of MOE and an organizer of the organizing country for the secondary school students aiming to promote Chemistry internationally.

Age criteria

Participants must be under 20 years on the 1st July of the competition year.

Language

Competition tasks are provided in English. But,the mentors can translate them into the language of participants' choice. Besides, translators may be registered on behalf of participating countries.

Delegates or Mentors

Each country has to send a delegate consisting of 4 participants and 2 mentors (including head mentor). They are considered as member of international jury.

Exam pattern

A mock exam is arranged by the host country just before the IChO under the similar condition of the main event.

The main competition involves 2 parts-

- Part I- Practical competition- total 40-points tasks in 4-5 hours' duration
- Part II- Theoretical competition- total 60-points tasks in 4-5 hours' duration

There exists at least1-day gap between the above two competitions. Non-programmable calculator is only allowed.

Safety during Practical competition

- The participants must put on laboratory coats with eye protection,
- In case of handling liquids, pipette ball or filler is delivered instead of pipetting by mouth,
- It is strictly forbidden to use acute toxic substances (except with special precautions).

Syllabus of IChO

The syllabus includes the topics taught in secondary school levels. They are-

- Theoretical skills
    i. Atomic Structure,
    ii. Periodic Table and trends,
    iii. Chemical Bonding,
    iv. Chemical Equilibrium,
    v. Electrochemistry,
    vi. Chemical Kinetics,
    vii. Thermodynamics,
    viii. Gas's Law,
    ix. Ionic Equilibrium,
    x. Photochemistry,
    xi. Solid State,
    xii. Inorganic Compounds,
    xiii. Organic Chemistry,
    xiv. Quantum Mechanics,
    xv. Spectroscopy.
- Practical skills
- Mathematical skills

Quadratic equations,Logarithms and Exponentials,Simultaneous equations,Trigonometry,Calculus.

Awards

In IChO, top 10-12 % of total competitors achieve Gold medals whereas following 20-22% receive Silver and the next 30-32 % get Bronze medals. The non-medallists who are in the best 70-71% receive HMs.

Preparations of the IPhO and IChO of India, Singapore and the USA

Indian preparation for IPhO and IChO

In India, HBCSE is the nodal center for science Olympiad run under TIFR, Mumbai. It maintains equity and excellence in science education from primary to undergraduate levels.

In India, IPhO and IChO follows mainly five stages (Singh & Kumar, 2010) and they are-

Stage 1:

National Standard Examination (NSE) in Physics and Chemistry referred as NSEP and NSEC

- Organized by- IAPT
- Centre- Held nationwide in centers at different schools
- Total participants- 20000-50000
- Probable date- November of previous year for Physics and Chemistry
- Duration- 2 hours for each subject
- Question pattern- Theoretical based Objective questions

Stage 2:

Indian National Olympiad (INO) in Physics and Chemistry

- Organized by- HBCSE
- Centre- Held nationwide in comparatively less numbered centers
- Total participants- 300-500
- Probable date- January- February of running year
- Duration- 4 hours for each subject
- Question pattern- Theoretical based objective and long questions

Stage 3:

Orientation-cum-Selection Camp (OCSC) in Physics and Chemistry

- Organized by- HBCSE
- Centre- HBCSE
- Total participants- 35-50
- Probable date- April/ May/ June of running year
- Duration- 2 weeks
- Question pattern- Theoretical and mainly experimental Sessions

Stage 4:

Pre-Departure Camp (PDC) in Physics and Chemistry

- Organized by- HBCSE
- Centre- HBCSE

- Total participants- 5 for Physics and 4 for Chemistry
- Probable date- July of running year
- Duration- 2 weeks
- Question pattern- Various rigorous theoretical and experimental Tests

Stage 5:

International Olympiad (IO) in Physics and Chemistry

- Organized by- International Olympiad host country responsible for that year
- Centre- International venue
- Total participants- 100- 400
- Probable date- July- August of running year
- Duration-10 hours over 10 days
- Question pattern- Theoretical and experimental competition

NSEP and NSEC (IAPT, n.d.)

a) General rules

- Conducted on 12th level students,
- Voluntary examination, not mandatory for all students,
- Started from every year since 1987, only exception in 2020-21 and 2021-22 when IOQP and IOQC have been conducted instead of NSEP and NSEC,
- NSEP conducted by IAPT whereas NSEC conducted by IAPT and Association of Chemistry Teachers (ACT),
- More than 200000 students at about 1500 centers (both in towns and villages) appeared in the examination,
- Registration fees of 150/ per student is applicable,
- Not linked with any entrance or scholarship award, but students (maximum 10) taking admissions in B.Sc. with Physics or Chemistry specialization get scholarships,
- Carried out in English, Hindi and few other Indian languages (for NSEP) and English (for NSEC),
- Its question paper and solutions are given to students after a week,
- Maintaining state-wise quota for selecting candidates in Indian National Physics Olympiad (INPhO) and Indian National Chemistry Olympiad (INChO)

b) Exam schedule (2023-24)

For NSEP- on 26th November 2023 (8.30- 10.30 am),

For NSEC- on 26th November 2023 (11.30- 1.30 pm)

c) Exam pattern (2023-24)

- **Online registration for enrolment of centers**

Date- 1st August- 20th August 2023

The following institutions can be registered for their students-

- High school,
- Senior secondary school,
- Higher secondary school,
- Junior college,
- Degree college etc.

- **Online registration for enrolment of students**

Date- 21st August -14th September 2023 (both days inclusive)

Eligible candidates- Students studying in 12th, 11th and 10th standards (not passing 12th) whose DOB must be within 1st July 2004 to 30th June 2009.

d) Syllabus

All chapters included in Physics and Chemistry textbooks of class 12 by National Council of Educational Research and Training (NCERT).

e) Question pattern

- **NSEP**

Total marks 240

Duration-2 hours

Part A1- Total 60 MCQ (Q1- Q60)

Each MCQ has 1 correct answer with 3 marks each and penalty of 1 marks.

Part A2- Total 10 MCQ (Q61- Q70)

Each MCQ has one or more than one correct answer with up to 6 marks.

➢ **NSEC**

Total marks 240

Duration-2 hours

Total 80 MCQ

Each MCQ has 1 correct answer with 3 marks each and penalty of 1 marks.

f) Results

Table 1.NSE - 2023 Result

Items	NSEP	NSEC
Average of top 10 scores	199.8	198.4
Merit Index (MI)	159	158
Minimum Admissible Score (MAS)	99	99
No. of students above MI	72	388
No. of students above MAS	912	3695

g) Certificates and Awards

In 2023, IAPT provides-

i. Certificates to 'Center top 10%' candidates,

ii. Merit certificates to 'State wise top 1%' students,

iii. Merit certificates and book prizes to 'National top 1%' students.

Cash rewards as well as books are provided to the meritorious students qualifying at each stage.

INPhO and INChO(HBCSE, n.d.)

a) Eligibility for INPhO and INChO

I. Impact of MAS and MI for determining eligibility (IAPT, n.d.)

➢ **MAS**

- It is determined by 50% of the average top 10 scores of the allied subject.
- A candidate must score it to be allowed for next level of selection in INO procedures.

➢ **MI**

- It is determined by taking percentage of the average of the top 10 scores,
- It determines the rank of the participants depending how they perform in NSEP and NSEC.

II. Participants who score more than 80% of the average top 10 scores, allowed for INO (informed accordingly).

III. Before sitting INO, candidate has to fix his subject preference in OSCS in case of sitting in multiple subjects.

IV. INPhO and INChO are conducted by HBCSE (TIFR) and ACT (for latter only) for class 11 and 12 after qualifying NSEP and NSEC respectively.

b) Exam schedule (2023-24)

For INPhO- 4th February 2023

For INChO- 3rd February 2023

c) INPhO

➢ **Norms**

- Separate question booklet and answer sheet are provided,
- After finishing of exam question booklet can be brought to home,
- Non-programmable scientific calculator is allowed.

➢ **Question pattern**

Total theoretical based 5 questions of 60 marks

Duration- 3 hours

Language used- English/ Hindi

d) INChO

➢ **Norms**

- Separate question booklet and answer sheet are provided,
- After finishing of exam question booklet can be brought to home,
- Non-programmable scientific calculator is allowed,
- A periodic table is provided.

➢ **Question pattern**

Total theoretical based 5 questions of 106 marks

Duration- 3 hours

Language used- English/ Hindi

e) Rewards

Gold medals will be awarded to top 35 students in the entire process. Besides, the participants of International Science Olympiads in Math and all four science subjects get automatically qualified for Kishore Vaigyanik Protsahan Yojana (KVPY) fellowship of Department of Science & Technology (DST) for continuing their study in science. The participants of IPhO and IChO get offers for direct admission to BARC for further studies in pure science. (Walawalkar, 2005)

OCSC (HBCSE, n.d.)

a) Eligibility

1% students whose marks are above cut off marks of INO, are informed of their selection by e-mail.

b) General rules

- Conducted by HBCSE of 2 weeks' duration,
- One student can participate into one OCSC at a time,
- Total 35 students are selected for each of IPhO and IChO OCSC.

c) Schedule (2023-24)

- IPhO OCSC (2024)- 17th April -30th April, 2024
- IChO OCSC (2024)- 29th April - 10th May, 2024

d) Results

- Cut off for IPhO OCSC (2023)- 31
- Cut off for IChO OCSC (2023)- 51

IO-PDC(HBCSE, n.d.)

- Conducted by HBCSE for 2 weeks,
- 5 candidates for IPhO and 4 candidates for IChO are selected finally to represent the nation.

Singaporean preparation for IPhO and IChO

Singapore Junior Physics Olympiad (SJPO) (IPS, n.d.a)

SJPO is organized by IPS which is famous scientific body in Singapore for study in Physics. The organization is run by elected members from National University of Singapore (NUS), Nanyang Technological University Singapore (NTU), National Institute of Education Singapore (NIE). IPS has the mission to promote and encourage Physics study in Singapore and thus provoking glorious achievements in SJPO and IPhO.SJPO was initiated in 2008 and then repeated in every year.

a) Eligibility

Secondary 1 to Secondary 4 students below age of 16 years (for main section) are applicable. For open section, there is no age limit. Students must apply through school; no individual application is granted.

b) Syllabus

It includes-

i. Mechanics of particles,

ii. Mechanics of rigid bodies,

iii. Fluid mechanics,

iv. Oscillations and Wave,

v. Electric charge and Electric field,

vi. Current and Magnetic field,

vii. Thermodynamics.

c) Exam pattern

Exam occurs in 2 rounds.

- General round-
  - Open to all students satisfying age limit,
  - Offline exam mode,
  - Total 50 MCQ type questions given,
  - Duration- 2 hours,
  - Scientific calculator allowed in both rounds.
- Special round-
  - Open to the students getting invitation only,
  - Offline exam mode,
  - A mixture of MCQ and structured questions given,
  - Duration- 3 hours.

d) Awards

Rank wise Gold, Silver, Bronze medals and HMs are provided.

Singapore Physics Olympiad (SPhO)(IPS, n.d.b)

SPhO was started from 1988 and then has been occurred every year in October/ November. No individual application is entertained. School wise applications are invited.IPS has organized 36th SPhO this year for the session 2023-24.

a) Syllabus

It is same as in IPhO.

b) Exam rule

- Only scientific calculator (non-programmable) allowed,
- General stationeries required for the exam allowed.

c) Exam pattern

- Theoretical round- Total 2 papers of 4 hours are to finish. (last year held on 21st October, 2023 at NIE) (SPOT, 2023a)
  - Paper 1- 5 questions (2 hours),
  - Paper 2- 4 questions (2 hours).
- Experimental round- Depending on the result of theoretical round total 50 students are selected for this round of 2 hours.(last year held on 23rd November, 2023 at NUS) (SPOT, 2023b)

d) Awards

Total 200 Junior College(JC) 1 students from various schools participated in 36th SPHO. Out of them total 80 candidates were awarded with 32 Gold medals, 19 Silver medals, 29 Bronze medals on 24th February, 2024 at National Junior College, Singapore. (SPOT, 2024)

Selection for IPhO

Finally, 5 members are selected to participate in IPhO depending on merit ranking.

Singapore Junior Chemistry Olympiad (SJChO) (SNIC, n.d.)

SJChO has been organized annually from 2010 by Singapore National Institute of Chemistry (SNIC) in association with NUS, NTU mainly and supported by Ministry of Education (MOE), Singapore. SNIC was founded in March 1970 as a national body to encourage chemical profession in Singapore.

a) Eligibility

All full time upper-secondary students of Secondary- 3,4, 5 are eligible. There exists no age limit.

b) General rule

- Periodic table is provided,
- Scientific calculator is provided,
- Only one attempt is provided to each student to enter the site before 30 mins of scheduled time of exam,
- The teachers have to monitor the exam and to prevent mal-practices only.

c) Syllabus

Same as GCE Ordinary Level, but the question pattern changes from simple to focusing on analytical,reasoning and creative skills.

d) Exam pattern

- Round 1 (to be held on 21st May, 2024 for running year)
    - Mandatory for all,
    - Duration- 2 hours,
    - Question pattern- Theoretical based 49 MCQ,
    - Marks allotment- 2 marks for each correct answer with no negative marking,
    - Exam mode- Online
- Round 2 (to be held on 25th June, 2024 for running year)
    - Selected students (top 20%) appear (from every 10 students from a particular school minimum 1 student is chosen for Round 2)
    - 1-2-hour practical exam to carry out a set of experiments,
    - Exam mode- Online

e) Awards

It will be held on August, 2024 in physical mode. All students appearing Round 2 get Gold, Silver, Bronze medals and HMs as per their rank. Despite of students' awards top performing schools also get awards. Thus the schools have 3 bands on the basis of their performances.

Singapore Chemistry Olympiad (SChO) (NUS, n.d.b)

SChO was initiated in 1989 and still continuing. It is jointly organized by SNIC, Chemistry Department of NUS and the MOE, Singapore.

a) Mission

- To promote students' interests in Chemistry,
- To prepare national team for IChO,
- To indulge Chemistry knowledge in depth of talented academically sound Chemistry JC students.

b) Eligibility

It is open for Junior College I students.

c) Exam pattern

Theoretical test and Practical test both are taken in a total duration of 4-5 hours taken over 2 days.

d) Awards

According to ranking of participating candidates, Gold, Silver, Bronze medals and HMs are provided. Despite that, 2 additional awards are given and they are-

- The best student award (for personal highest overall score),
- The best team award (for the school with the highest combined score of its best 3 participants)

Team selection for IChO

In every year, the process of IChO team selection process comprises of 2 rounds of tests.

➢ **Round I**

Here amongst 150 participants, about 25 ones are selected for rigorous special training for IChO. This group is co-trained by NUS/ NIE lecturers Junior College teachers. Through this training programme, the participants experience expert lectures, practical lessons, problem solving methods and tests. This are held on Wednesday afternoon from February to May every year. It also includes 1 week of intensive training during the school holidays of March and June.

➢ **Round II**

Here finally 4 students are selected on the basis of their merits as well as performances in tests. They undergo 14 days of intensive training which also includes 7 days of residential training in NUS during June vacations.

The entire training process actually runs for 2 years and it involves Team Leader and Deputy Leader of IChO who are generally lecturers of NUS and JC respectively.

American preparation for IPhO and IChO

No Chemistry Olympiad for middle-school students has been found in the USA.

U. S. Physics Olympiad for middle-school students(Physcira, n.d.)

a) Mission

With a mission for providing better STEM based classroom teaching and making STEM workforce in future, Physcira (Physical Science Research Associates), the nation's leading company initiated to organize an Olympiad exam for mainly middle-school students, named 'U. S. Physics Olympiad for middle-school students' launched for first time in 2021. Now, it is 4th year in a row.

American firms, various national laboratories including Govt. organizations always support this virtual event.

b) Eligibity

Students of class 6, 7, 8 can sit for this competition being guided by their teachers who can fill up the application form on behalf of them in just 15 mins window period.

c) Fee structure

No application fee is needed.

d) Exam schedule (running year)

Exam on 28th March, 2024 (one-day virtual event)

Result on 29th March, 2024

e) Syllabus

i. Mechanics,

ii. Optics,

iii. Electricity,

iv. Magnetism.

f) Exam pattern

- **Part I**
  - 25 MCQ to be done in 90 mins,
  - Exam window opens from at 8am to 12pm according to participant's local time,
  - The coach of the student has to receive the question paper and to submit the completed scanned answer sheet within the given time period.
- **Part II**
  - 6 open-response, pre-algebraic type problems of Physics to be solved in 90 mins,
  - Exam window opens from at 1 pm to 5 pm according to participant's local time.

g) Awards

All participants are provided certificates. Special certificates are provided to special performers.

U. S. Physics Olympiad (AAPT, n.d.)

Preparing U S Physics Team every year for IPhO is sponsored by the AAPT (established in 1930) and the AIP with a bird view of promoting and demonstrating academic excellence by U. S. Physics Team in IPhO.

F=ma exam

Students aspiring to sit in IPhO and to be the member of U S Physics Team has to crack 'F=ma' exam first.

a) Eligibility

- Students must not exceed age 20 by June 30 of the competition year of IPhO,
- Candidates must be U. S. citizens or U. S. permanent residents (Green Card holders) or attend a U. S. school.

b) Exam pattern

- 25 MCQ based on Mechanics
- Duration- 75 mins
- No negative marking

c) Fee structure

- Fees are allotted for individual ($ 15) as well as school ($ 75) registration in 2024.

d) Exam schedule

- Exam window remains open for 10-12 hours on the exam day.
- Exam day- 8th February, 2024 (for running year).

e) Exam center selection (for both F=ma and USAPhO exam)

Students are advised preferably to choose their exam centers at local school. Home schooled students have to contact Community Colleges or Universities or Libraries. AAPT does not take any responsibility regarding this.

f) Proctor selection (for both F=ma and USAPhO exam)

Students have to maintain some check lists for proctor selection due to. They are-

- ✓ Parents and relatives are not allowed as proctors,
- ✓ Proctors must have a minimum 2-years degree not related to Physics,
- ✓ All the integrity should be maintained while participating from a public library center,
- ✓ Proctor must be verified through official e-mail id with proper identification.

g) Duty of a proctor (for both F=ma and USAPhO exam)

Proctor has to print PDF question sheets of both F=ma and USAPhO exams and send scanned completed answer sheets to AAPT through e-mail.

h) General instructions (for both F=ma and USAPhO exam)

- All students appearing from the same school, have to sit for exam in same time,
- Handheld calculators are allowed,
- Students have to hand over answer sheets and scratch papers to the proctor after finishing exam.

USAPhO exam

On the basis of the score obtained in F=ma exam, total 400 students are selected to participate in USAPhO exam.

a) Eligibility

- During the exam, candidates must be located in USA. (other is as same as F=ma exam)

b) Syllabus

i. Introductory Physics,

ii. Mechanics,

iii. Electromagnetism,

iv. Thermodynamics,

v. Relativity,

vi. Nuclear Physics,

vii. Atomic Physics,

viii. Particle Physics,

ix. Waves,

x. Optics,

xi. Data analysis.

c) Exam pattern

- Freely response questions provided,
- Duration- 3 hours (90 mins for each of two parts)

d) Exam schedule

- Exam window remains open from 1 pm to 6 pm on the exam day.
- Exam day- 2 April, 2024 (for running year).

e) Awards after USAPhO

- Just similar to the IPhO, in USAPhO first 10-12 % get Gold medals followed by 14-16 % Silver Medals, 20-22 % Bronze Medals and 24-26 % HM depending on the cut off of that particular year.

U. S. Physics Team Training Camp

On the basis of F=ma and USAPhO exam, 20 students are selected and they have their full 10-day compulsory training at University of Maryland. (from 31st May, 2024 tom 11th June, 2024 for running year)

Finalization of U. S. Physics Team

After the training camp, 5 students are finally selected to represent the USA in the IPhO through the 'main theoretical team selection test' of 5-hour duration covering total 3 problems each of equal points held on U. S. Physics Team Training Camp at College Park, Maryland. Students are provided answer sheets, scratch paper, hand-held scientific calculator with all memory erased and a computer to upload the answers in 20 mins after termination of exam.

U.S. National Chemistry Olympiad (USNCO) (ACS, n.d.).

USNCO has 4 steps. They are-

Step 1

Local Chemistry Olympiad exam

- Held in March every year,
- Applicable to high school students registered with ACS,
- Host- ACS Local Sections at local universities and colleges,
- Language of question paper- English (USNCO coordinators are allowed to translate the question paper in participant's own language),
- Question pattern- 60 MCQ,
- Duration- 110 mins,
- Periodic table is supplied,
- Answer sheets and scratch work papers supplied to be returned after finishing of exam,
- On basis of score at Local level exams, candidates for National level exams are chosen by the ACS Local section coordinator.

Step 2

National Chemistry Olympiad exam

- Held in April every year,
- Total participants- 1000 (about),
- Host- ACS Local Sections at local universities and colleges,
- Language of question paper- English only,
- Exam pattern- conducted in 3 parts.

I. **Part I-** 60 single answer MCQ (time- 1 hr 30 mins)

II. **Part II-** 8problem solving/ explanation based questions (time- 1 hr 45 mins)

III. **Part III-** Laboratory practical of2 lab problems (time- 1 hr 30 mins)

- Syllabus

  For Part I exam each topic includes 6 MCQs and the topics are-

  i. Stoichiometry/ Solutions,

  ii. Descriptive/ Laboratory,

iii. States of Matter,

iv. Thermodynamics,

v. Kinetics,

vi. Equilibrium,

vii. Oxidation/ Reduction,

viii. Atomic Structure/ Periodicity,

ix. Bonding/ Molecular Structure,

x. Organic/ Biochemistry.

Step 3

Study camp

- Held in June every year,
- Total participants- Top 20 scorers of National level exam,
- Training centre- Study Camp,
- Duration- 15 days,
- After training, 4 candidates are chosen to participate in IChO for the USA and they are guided by USNCO mentors.

Step 4

IChO exam

The 4 competitors chosen for IChO along with their mentors participate in IChO where they can translate test or inspect laboratories or negotiate the exam-score after interacting with one another.

Some aspects of Chemistry Olympiad are-

a) Eligibility

- Citizenship criteria as same as USAPhO,
- For local level exam, all high school students from class 9 to 12 (not completing graduation before May) and those completing advanced placement course in Chemistry are eligible,
- Students have to appear from the same area of section of their own school,
- U. S. students living abroad can participate for local and national level exams if they complete last 1-year from an American school,
- USNCO provides permission to the aspiring disabled persons for their accommodations on basis of the verification of their medical reports,

- The question paper may be translated to braille for blind and visually impaired people on the basis of prior application.

b) Age criteria

Student's ageshould be within 20 years on 1st July of the participating years.

c) General rules

- Maximum 2 students per high school are allowed for National level exam (except previous years' students, who attend Study camp, get direct entry to Study camp for running year),
- Local ACS coordinators are allowed to nominate only fixed number students which is determined by the number of its ACS members,
- Cyber-school can also nominate maximum 2 cyber-students for local exams choosing area of section depending on their geographical location,
- A student can't join the study camp for Chemistry along with that of other science subjects simultaneously,
- Students once get a Gold medal in IChO, can't participate in the succeeding National level exams, Study camps or IChO,
- Only non-programmable calculators are allowed.

d) Insurance

Though all laboratory practical sites are investigated properly, ACS covers all the insurance for the participants of Chemistry Olympiad Programme overviewing their risks in lab-based activities.

Findings and Comparative analysis

Performances of three countries in IJSO

IJSO has been started from 2004 and still continuing. Till then, India not only has been a participant (except 2020), but the nation has also signed with its marvellous achievements. Singapore has participated three times in IJSO in 2007, 2008 and 2011. But, the USA never participated since the beginning till 2023. The country just remains as observer in 2008.(IJSO,n.d.)Performances of India and Singapore have been shown in Table 2.

Table 2: Comparison of performances among three countries in the common participating years in IJSO (IJSO, n.d.)

Name of the countries	2007			2008			2011		
	GM	SM	BM	GM	SM	BM	GM	SM	BM
INDIA	0	3	0	0	5	1	2	4	14
SINGAPORE	4	2	0	3	3	0	3	3	15

Note: GM= Gold Medal, SM= Silver Medal, BM= Bronze Medal, HM= Honourable Mention

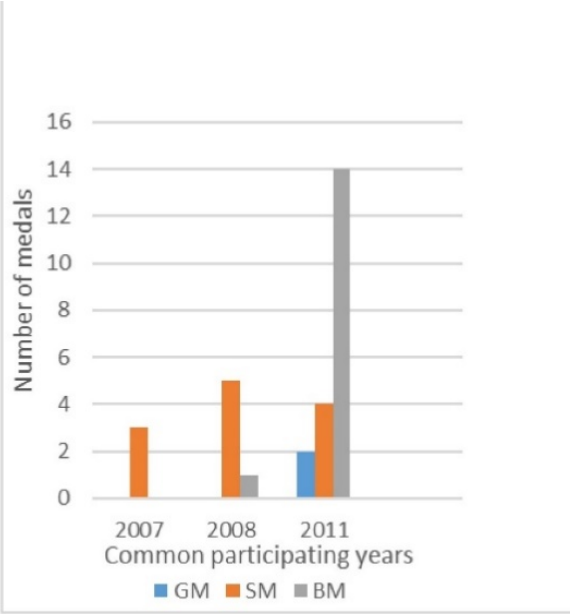

Fig 1: Performance of India in IJSO

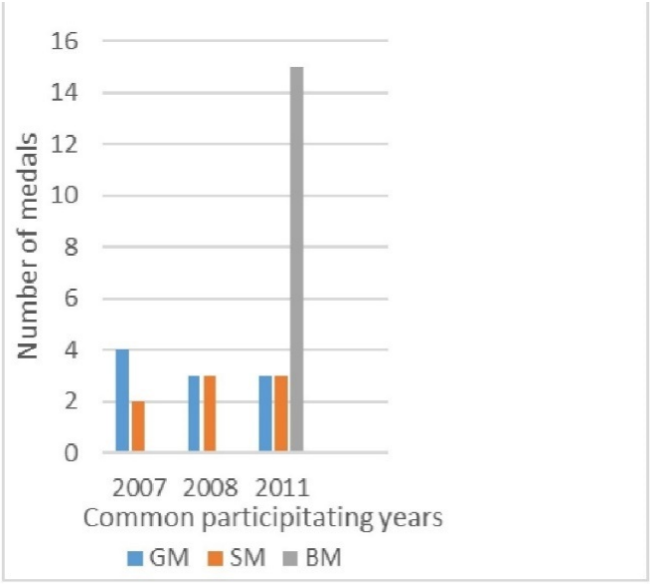

Fig 2: Performance of Singapore in IJSO

India has acquired 1st rank for 4 times in IJSO by bagging all 6 Gold medals. These are in 2014 (11th IJSO, Argentina) and three consecutive years 2019 (16th IJSO, Qatar), 2021 (18th IJSO, UAE) (ISW, 2021) and 2022 (19th IJSO, Colombia) (PIB Mumbai, 2022) as the country didn't participate in 2020. In 2023, India ranked 2nd after Chinese Taipai. But, it has restored its position in 2024 by securing 1st position again. Table no. 3 shows the marvellous and magnificent results of India in the last 5 years of IJSO clearly.

Table 3: India's performance in IJSO in the last 6 years (2019-2024) (IJSO, n.d.)

Participating year	Total medals awarded			Absolute rank of the country
	GM	SM	BM	
2024	6	0	0	1st
2023	5	1	0	2nd
2022	6	0	0	1st
2021	6	0	0	1st
2020	Not participating			
2019	6	0	0	1st

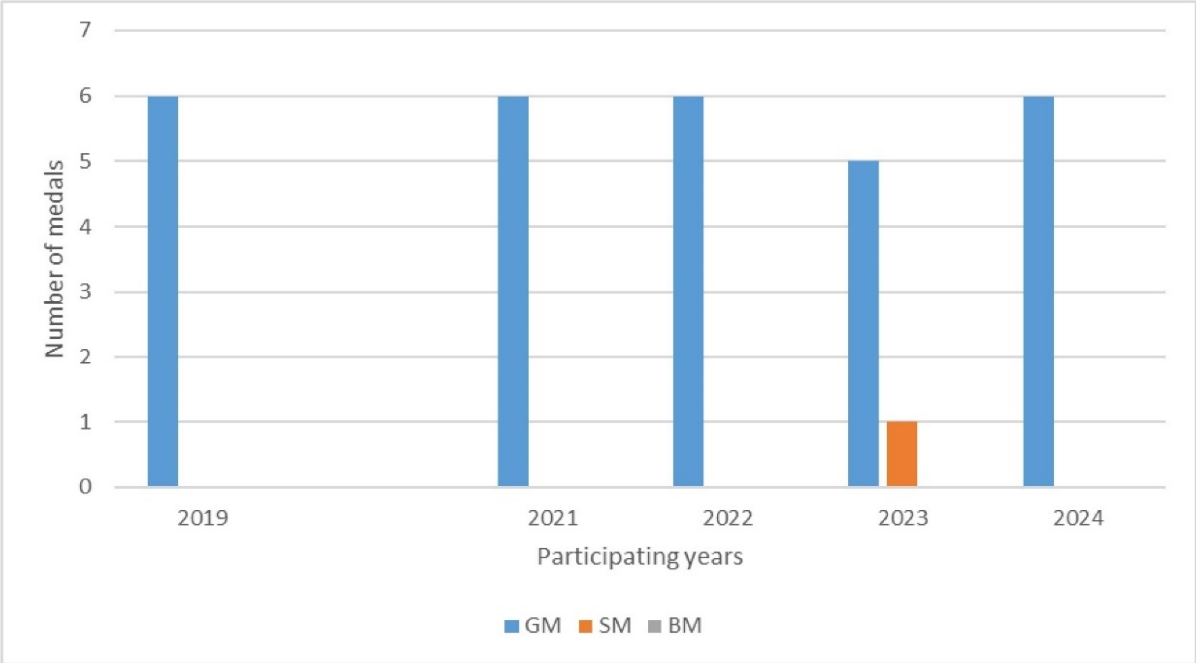

Fig 3: Performances of India in last six years in IJSO (2019-2024)

For Singapore and the USA, no preparation and practice has been found for IJSO particularly. However, there exists a Science Olympiad for lower secondary and middle school in specific science subjects like Physics and Chemistry. 21st IJSO was held in Romania in December, 2024 for the deadline date for registration was 31stMarch, 2024.

Performances of three countries in IPhO

From the performances of the 3 countries in IPhO (see Table 4), it has been revealed that though India started her journey in IPhO almost 1-decade after Singapore, she has lagged by just 10 medals from Singapore. The performance of the USA in IPhO is just outstanding. The country initiated its journey just 3 years before Singapore but has achieved 35 more medals in the category. But, it has been found that, from 2009 to 2019 all the aforesaid 3 countries have achieved same number of total medals and that is 55. (Kreminsky et al., 2021) So, the difference in total number of medals mainly exists in the initial years of participation. The 54th IPhO has been organised in the Islamic Republic of Iran from 21st July 2024 to 29th July 2024. Though India has participated in the event and bagged 2 gold and 3 silver medals, Singapore and the USA has abstained from participating.

Table 4: Performance at the IPhO of India, Singapore and the USA between 1967-2024

Country	First participation	Observer	Number of participations	GM	SM	BM	HM	Total medals
India	1998	1997	25 (except 2020, 2021)	51	53	14	7	118
Singapore	1989	-	35 (except 2024)	49	47	27	25	123
USA	1986	1985	37 (except 2002, 2024)	78	51	29	11	158

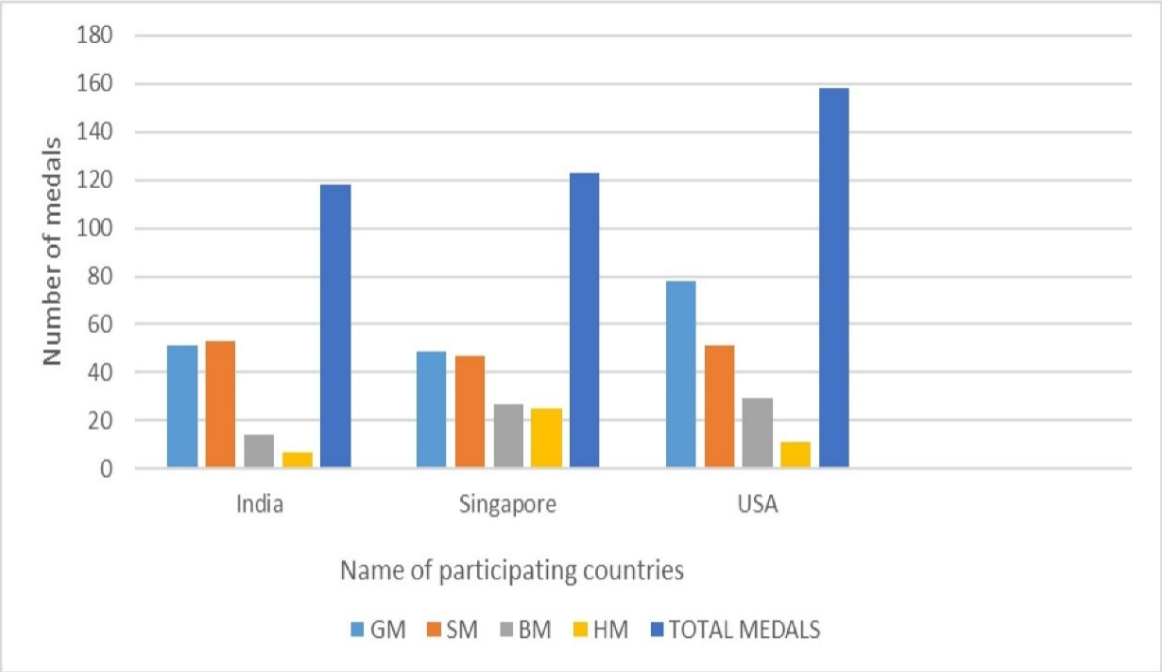

Fig 4: Performances of three countries in IPhO (till 2024)

Hosting of three countries in IPhO

All the 3 countries have hosted once the IPhO as revealed from Table 5. But the performance of the USA is best among them. The country has dared to host the event just after 7 years of its first participation (see Table 5) and has ranked 9th among 42 participating countries. Whereas, Singapore has started participating from 1989 and taken 17 years to host the event with 15th rank out of 82 countries. In this respect, India is almost comparable with that of Singapore because India has started its journey after 9 years than that of Singapore and hosted IPhO just after 9 years than that of Singapore with almost close absolute ranking.

Table 5: Hosting IPhO by India, Singapore and USA between 1967-2024 (IPhO, n.d.)

Host country	Number of hosting IChO	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	17
Singapore	1	2006 (37th, in Singapore)	82	1	1	3	0	15
USA	1	1993 (24th, in Williamsburg)	42	1	1	2	1	9

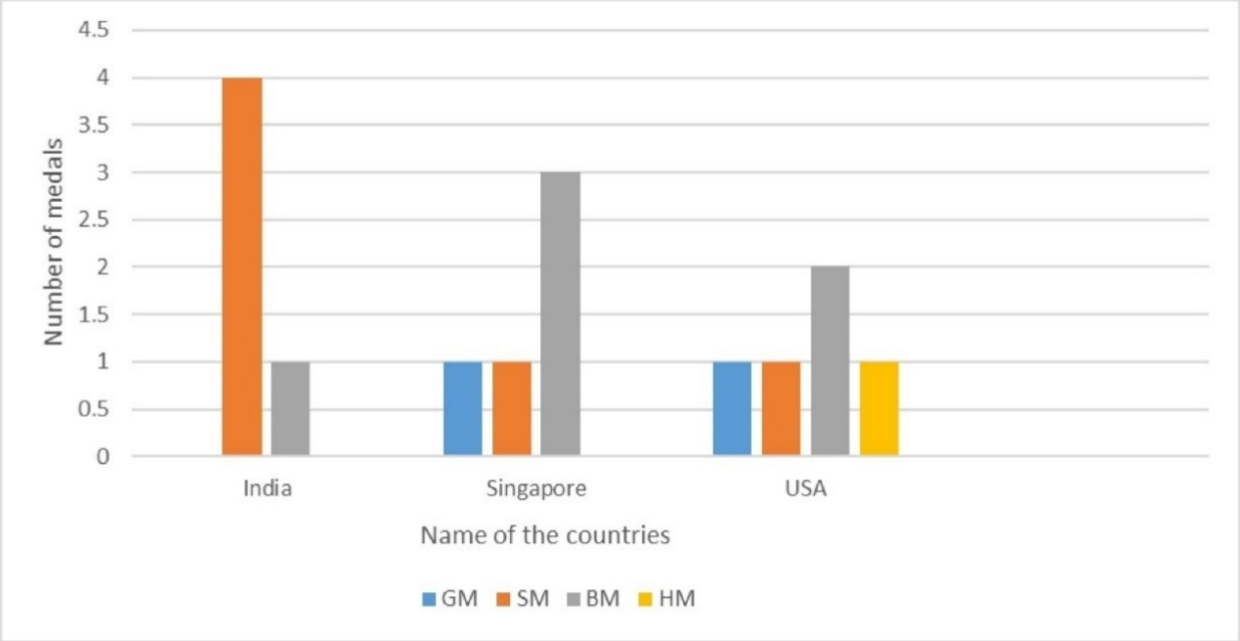

Fig 5: Performances of the countries at the year of hosting IPhO

Performances of three countries in IChO

Performances of 3 countries in IChO are shown in the table no.6. Though India has started late, but the country has managed to bag 4 medals (each for every participant) every year of its participation. Whereas, the USA being the table topper, has received 1 HM in 1986 with less than 4 medals 3 times (1984, 1987, 1989) in the history of IChO. Singapore, being the highest rank holder (4 Gold medals) in 2023, also has achieved less than 4 medals 4 times (1988, 1990, 1991, 1995). The 56th IChO will be organized in Riyadh, Saudi Arabia from 21st July, 2024 to 31st July, 2024.

Table 6: Performance at the IChO of India, Singapore and USA between 1968-2024 (IChO, n.d.)

Country	First participation	Number of participations	GM	SM	BM	HM	Total medals	Highest rank obtained (year)
India	1999	25 (except 2020)	29	53	18	0	100	-
Singapore	1988	36 (except 1989)	45	59	36	0	I40	1 (2023)
USA	1984	40 (every year)	55	72	33	1	160	3 (2017, 2018, 2020)

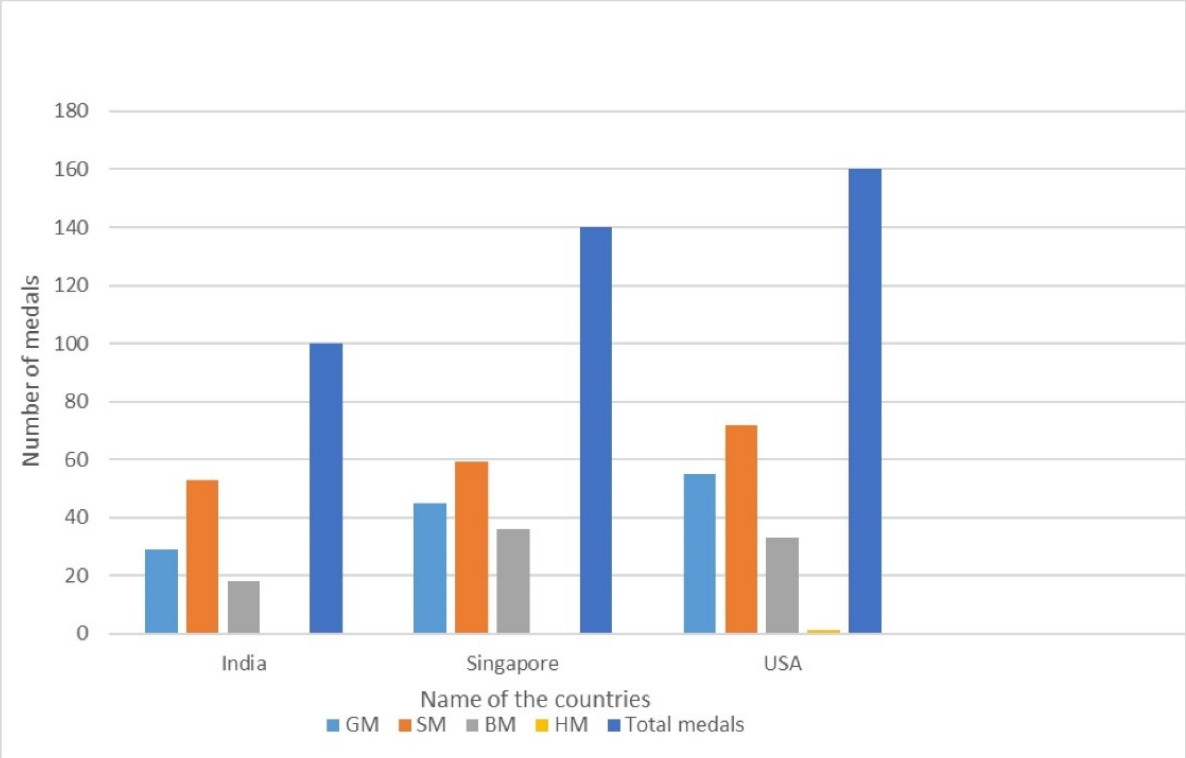

Fig 6: Performances of three countries in IChO (till 2024)

Hosting of three countries in IChO

Though Singapore has performed extraordinarily throughout in IChO (specially in 2023), it has never hosted it. But India has hosted IChO in 2001, just after 2 years of its first participation (see Table 7) and also achieved 1 Gold and 3 Silver medals. It is really very praiseworthy. On the other hand, the USA has hosted IChO twice since 1984, but cannot occupy highest rank in those hosting years.

Table 7: Hosting IChO by India, Singapore and USA 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
USA	2	1992 (24th, in Pittsburgh)	33	1	2	1	0	16	27	40	0
		2012 (44th, in Washington, DC)	71	1	3	0	0	34	59	87	10

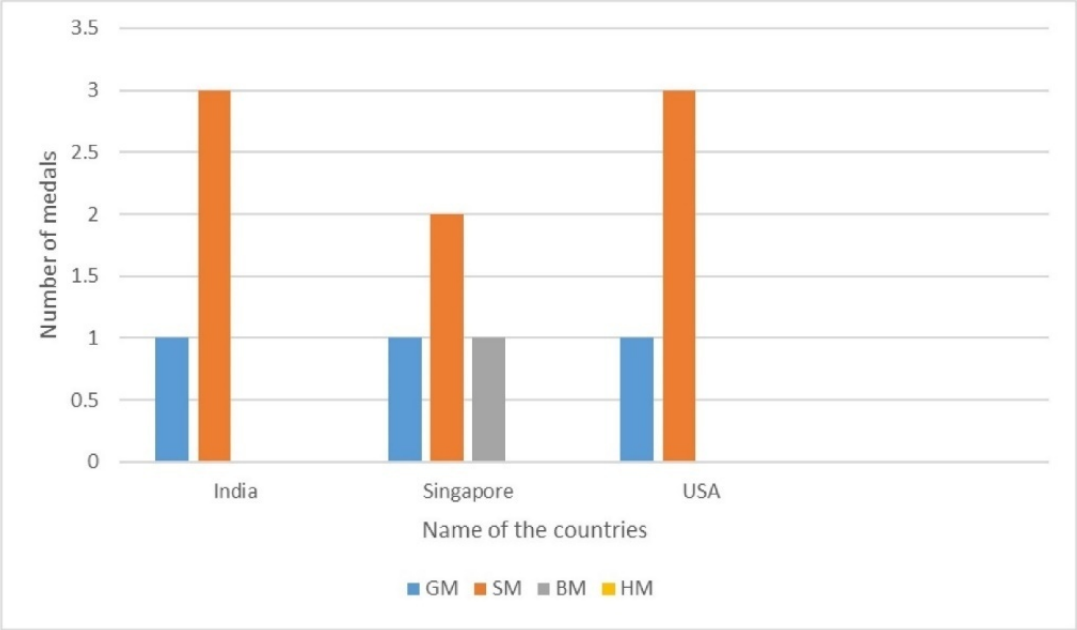

Fig 7: Performances of the countries in the year of hosting IChO

Recommendations

India has beaten the aforesaid two countries along with many countries in IJSO due to mainly two reasons-

- Its integrated, composite science curriculum specially in upper-primary (middle school) and secondary section, (Nandy & Pramanik, 2024, Ghosh & Pramanik, 2024)
- Teaching science as an interdisciplinary subject,
- Proper guidance by the science teacher,
- High level preparations and rigorous practices for IJSO.

On the other hand,the scenario changes for IPhO and IChO.

- It is needless to mention that the performances of Singapore and the USA in IPhO and IChO are better than that of India. This is mainly due to their goal-oriented, target-specific science curriculum followed in secondary level and its execution through proper professional guidance. Here, the role of the science teachersand their professional development is noteworthy.
- Science teaching should be done through hands on training vividly from lower secondary (class 9 and 10) onwards although small introductory experiments can be carried out from class 6 onwards. As a consequence, students get more interests in science subjects and aspiring students for Science Olympiads get sufficient time to bug up the experimental section more accurately.
- In India, the practical part of science syllabus is mainly followed in class 11 onwards. Besides, they have to complete the vast theoretical part of syllabus of Physics and Chemistry also. It appears to be some troublesome for higher secondary (class 11 and 12) students to keep balance between the both parts of syllabus in such a short duration. So, preparation for Science Olympiad should be started from early stage for more glorious results.

- HBCSE has taken the responsibility to create modern and more improved laboratories and thus National Initiative on Undergraduate Science (NIUS) is formed in 2004 along with many other science and research institutes on national level. (Singh & Kumar, 2010) Many more has to be founded nationwide.
- The transition in science curriculum from lower secondary to higher secondary is not very smooth. Initiatives should be taken to reduce the difference.
- As Mathematics is compulsory for IPhO and IChO, so learning Mathematical knowledge is necessary.
- As the questions in IPhO and IChO are based on interdisciplinary concepts, so the practice in science curriculum should be in per that.
- Indian students may be retarded due to language problem specially in IPhO.
- Science Olympiads in national level should be started from junior class to make the students accustomed with the international contests.

Conclusions:

In spite of having third highest population in the world, the USA performed very well throughout in IPhO and IChO. Whereas India with highest population in the world has lagged behind in those events. This is actually due to planned, goal-oriented science curriculum of the USA which is based on Next Generation Science Standards (NGSS) in Science Technology Engineering Mathematics (STEM) based classroom of the USA. Though India has started late, the country tried its best to achieve its best. India has achieved 4^{th} position just after USA (3^{rd}) in IPhO, 2023 which is more praiseworthy than the result in IPhO, 2022: when the country has ranked 9^{th} with the USA in 4^{th} position. Singapore with very less population has managed to start its journey 9 years before than India in both IPhO and IChO. It has ranked (9^{th}) as same as India in IPhO, 2022 but lagged behind in IPhO,2023 with its 14^{th} rank. Simultaneously, Singapore has performed extraordinarily in IChO, 2023 by occupying 1^{st} rank and made a history.

Within India, Singapore and the USA, though India has started its journey in Science Olympiads with comparatively less ranking just like in Mathematics Olympiad (Pramanik & Guha, 2019; Pramanik, 2019), but the country has proved itself more improved and developed year by year, not only with its hard effort, but also with its strong determination and will power.

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