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Comparison of Curriculum of School Science Education of India and Singapore: A Comparative Study

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Abstract
The purpose of this study is to discuss and compare the curriculum for school science education between India and Singapore. Researchers followed qualitative data analysis methodology along with a comparative investigation strategy. The fundamental difference is India's curriculum has emphasized rote learning over creativity, whereas Singapore cultivates creativity among its pupils. Through NEP 2020, Govt. of India has stepped forward to make up this unavoidable gap. This study compares the school education system, analyzes the science curriculum, and compares the curriculum of school science education between India and Singapore. No comparative study in this regard has been found in the literature which reflects the originality of the study.

Keywords
Science education, School science education, Science curriculum, Comparative study, NEP-2020

1. Introduction
After independence in 1947, India has engaged in self-reliance as well as sustainable and equitable growth. The country struggling for food grains once, now, is eligible for its own production not only in agriculture but also in new research and development works, making satellites and IT hubs and a strong industrial belt. The country is now eligible to produce scientifically and technically trained manpower although having the largest population in the world (retrieved from http://www.worldometers.info) with 17.47% of the total world's population. But, despite all of this, science education in Indian schools is facing challenges nowadays mainly due to a lack of three wings: a) adequate equipment, b) trained teachers, c) constructive science curriculum (Sarangapani, n.d.). On the other hand, another Asian peer country Singapore with a very less population of 5.97 million (retrieved from http://wwws.worldometers.info), being a sovereign city-state, has remarkable performance not only in various international assessments (like PISA, TIMSS, etc.), but also makes prepared their people with a skilled workforce. As the country has very few natural resources and has to import almost everything that it needs, the Govt. of Singapore provides immense importance on science education to help the next generation to find out and amplify their competencies, capabilities, and potential in a plenary way and cultivate creativity as well to face the ever-evolving world. Therefore, the science education curriculum plays a vital role in this context and is concentrated on the concept of 'Science as inquiry'. Here is the point of interest for researchers to find out the reason for such type of disparities mainly in the curriculum of science education of two countries from a brief historical background to recent contemporary change.

2. Literature Review
As per van den Akker (2010), the definition of 'curriculum' may vary, but in essence, though it 'a plan for learning' was implicated. It may be defined as a pack of guidelines that need to be followed for both students learning and their teaching in the education system.

OECD (2020) in its Working Paper No. 239 mentioned that curriculum reforms specify the involvement for change in objectives of learning depending on the necessity of student's competencies, knowledge, values, and attitudes to cope with the fast-changing world as the schools enter the 21st century. Curriculum reform has progressively shifted its vision from a 'top-down' approach to a 'bottom-up' approach emphasizing the central role of teachers in the process.

Mathew & Balachandran (2018) showed the differences prevailing in the educational system of India and Singapore and pointed out some propositions for India for extensive learning practices among students.

Pramanik and Guha (2018) showed that for mathematics study between India, China and the USA, the third country showed maximum flexibility while designing curriculum effective for its different states.

Vaidiyanthan (2020) suggested that by updating the curriculum and teaching methods India made the next generations able to think critically and produced a workforce for a future economy with compared to Singapore.

Sarangapani (n.d.) concluded that science education in Indian schools was facing challenges mainly due to a lack of three wings- a) adequate equipment, b) trained teachers, c) constructive science curriculum.

Kumar & Singh (2018) found in their article that every Indian should inculcate, propagate and disperse scientific temperament in society as their constitutional right. They suggested the development of science subjects as a process at the curriculum level, acquainting students with the nature of science as a pedagogical component and thus making science education productive and enjoyable to learners.

OECD (2011) showed the reason for rapid improvement and its persistence in the case of Singapore's education system and focused on how the government of Singapore successfully balanced the supply and demand of education.

Poon (2014) found in his study that after self-governance in 1959, Singapore government shifted its focus from providing skilled manpower to an inquiry- centered science education in 21st century. From 1960s, the entire system for science education through teaching along with learning within the classroom situation had been transformed from the viewpoint of a little nation to one of the respected international countries for its continuous achievement in international mathematics and science studies.

Maxwell (2017) concluded that four factors were attributed to the high achievement of Singapore's successful educational system and they were curriculum, pedagogy, teaching standards, leadership development, and culture.

Yue (2014) found that the Government of Singapore took dominance and very high-quality leadership to come out of the troubles by moving towards a 'knowledge-based economy'.

3. Research Gap

No comparative study has been found to date about the curriculum in school science education of India and Singapore from primary to higher secondary level. The study has focused to fill that gap.

4. Objectives

Objectives of this study are-

- To compare the school education system of India and Singapore,
- To analyze the science curriculum of two countries comparatively with contemporary change,
- To compare the science curriculum of the two countries.

5. Methodology

a) General methodology: *Qualitative study*
b) Methodology: *Few-country comparison*
c) Comparative method: *Case-oriented studies, Document analysis, Content analysis*
d) Research materials: *Government documents, books, articles and book chapters in edited volume, peer reviewed journals, newspaper, blog*
e) Data collection process: *Multiple procedures consisting of studying journals (print and online both), books, newspapers, periodicals have been used.*
f) Data analysis: *The study has employed the current document-based analytical approach. To analyze the collected data historical and sociological strategies have been adopted.*

6. Major Findings

6.1 Overview of the Structure of Indian School Education Systems

India operates (5+3+2+2) system.

According to NCERT 2006, the stages of school education are as follows:

I. Primary (class1-5): 5-7 years of schooling, approximately 5-11 years of age
II. Upper Primary (class6-8): 6-8 years of schooling, 12-14 years of age
III. Secondary (class9-10): 9-10 years of schooling, 15-16 years of age
IV. Higher Secondary (class11-12):11-12 years of schooling,17-18 years of age

After the Higher Secondary Board examination, various types of tertiary education started both general and technical types.

6.2 Educational Structure of Singapore

Singapore operates (6+4+2) system.

I. Primary (Grade 1-6): 6 years of schooling- Foundation Stage (1-4) + Orientation Stage (5-6)

II. Secondary (Grade7-10): 4-5 years of schooling-

a) Special/ Express course 4 years GCE 'O' Level of Science
b) Lower Secondary Normal (Academic) Science course 4 years/GCE 'N' Level Science syllabus 'A' with an additional 1 year/GCE 'O'Level Science Syllabus
c) Upper Secondary Normal Technical Science Course 4 years/GCE 'N' Level Science Syllabus 'T' with Additional 1 year/GCE 'N' Level Science Syllabus 'A'

There are two years of tertiary education. Meanwhile, tertiary education is of two phases. These are Junior College, Polytechnic, and university education.

6.3 Science Curriculum Development in India

The NCERT and SCERT are taking decisions regarding curriculum design for school education in India. The NCERT brought many National Curriculum Framework (NCFs) in 1975, 1988, 2000, and 2005 respectively. The school science education follows the guidelines of NCF 2005.

6.3.1 Aims of Science Education

According to NCF-2005, science education will enable the learner to

- Know theories and applications of science to boost their cognitive development indicating *cognitive validity*,
- Adapt the curriculum which is needful and simplified in context excluding meaningless concepts thus comprising *content validity*,
- Help the learners in acquiring process leading to generate and validate scientific knowledge and thus inspiring curiosity and creativity of students and satisfying *process validity*,
- Build up a historical and developmental perspective of science where science can be explained as a social enterprise. Here *historical validity* is explained,
- To make them prepared for facing the ever-challenging world and for adjusting to the environment and thus validating the *environment validity*,
- Construct the values like honesty, and objectivity, be fearless as well as bias less, be cooperative cultivate a 'scientific temper', and to be aware of life and environment conservation, thus maintaining *ethical validity.*

6.3.2 Science Curriculum Development in different stages Primary stage

a) Joyful involvement of the child,
b) Engagement in exploratory and hands-on activities, thus rearing up curiosity (psychomotor skill),
c) Emphasizing on design and fabrication, estimation and measurement, thus improving technological and quantitative skills for a later stage,
d) Acquiring basic cognitive skills,
e) Developing basic language skills,
f) Studying 'Environmental Studies' as an integrated subject with health as an important part.

Upper Primary stage

a) Realizing scientific principles relating with the environment through activities and surveys and familiar experiences,
b) Studying through group activities,
c) Designing simple technological units and modules on hand.

Secondary stage

a) Including science as a composite discipline,
b) Making more advanced tools scientifically and technically sound,
c) Perceiving knowledge on the basis of environment and health,
d) Indulging in systematic experiments to discover/verify theoretical principles,
e) Involving in local scientific projects.

Higher Secondary stage

a) Introducing separate disciplines of science such as Physics, Chemistry, and Biology emphasizing experiments with the ability of problem- solving,
b) Introducing two streams which are academic and vocational,
c) Offering subjects as crediting students' choice,
d) Rationalizing the sharp difference between secondary and higher secondary syllabuses.

6.3.3 Effects of NEP 2020 on School Science Curriculum

The new and latest education policy of India is NEP 2020 which is not still conquered in its full phase. According to it, the new school education system follows (5+3+3+4) curricular structure. Major instances for school science curriculum conferred by it are-

i. Fact-oriented and scientific thinking through the curriculum,
ii. Inspiring creativity and innovation,
iii. Attempt to diminish the differences between 'arts' against 'science', 'academic' versus 'vocational' course or 'curricular' and 'extra-curricular' activities,
iv. literacy and computational thinking, nationhood etc.,
v. Science learning in a more interactive manner encouraging collaborative and exploratory activities through experiential learning,
vi. Extensive, appropriate and equitable use of technologies,
vii. Increasing flexibility in case of choosing inter-disciplinary subjects,
viii. Reducing overload of science content,
ix. Getting Foundational Literacy and Numeracy (FLN) while reading in class 3.

6.3.4 NCF 2023

According to NCF 2023, the four stages of school education should be improvised as:

Foundational stage (from the age of 3 to Grade 2)

Schooling of a child begins at the age of 3 which is flourished on the ethos of Early Childhood Care and Education (ECCE) and continued up to Grade 2. Introduction of textbooks occurs only from Grade 1 with development of early language, communication along with literacy as well as numeracy.

Preparatory stage (Grade 3 to 5)

Like foundational stage learning should be continued through playing, discovery and full of activities. In accordance, inclusions of text-book and formal classes also are done. Introductions with generalist to subject specific concept and that with corresponding teachers also have done in this stage.

Middle stage (Grade 6 to 8)

Maintaining the balance with Preparatory stage, the science education should be more inquiry based and understanding based. It should be in a blended form with social science and vocational education. Curriculum will be more subject-specific.

Secondary stage (Grade 9 to 12)

Multidisciplinary and choice-based courses are introduced and encouraged from secondary level without maintaining any specific borderline between arts, science, humanities, vocational along with curricular and co-curricular activities. 'Greater breadth' and 'greater depth' both the concepts are envisioned through students' curriculum. Students have to complete 'sixteen essential courses' within grade 10 and 'sixteen choice-based courses' within grade 12.

6.3.5 Developing 21st Century Capacities as mentioned in NEP-2020

It comprises of-

i. Communication in all way,
ii. Capability of using more than one language,
iii. Science-oriented temperament,
iv. Art and Craft and its aestheticism,
v. Ability to solve problems,
vi. Sustainability in living,
vii. Literacy about our culture,
viii. Balanced sociological and emotional attributes,
ix. Indulging in lifelong learning.

6.4 Science Curriculum Development in Singapore

6.4.1 Science Curriculum Framework

'Science for Life and Society'- a tagline at the core of this framework directs the goals of science education.

6.4.2 Science Education and its Goal

- To provoke and make all the students have scientific literacy which guides them to have their own decisions. They will be responsible for their livelihoods,

- To develop strong science background for learners to innovate and pursue STEM for their future lives and works.

6.4.3 Science Education and its Vision

It covers the desired and overall learning outcomes of students studying science education through three underlying principles:

- Inspired by science- Students enjoy the science subject not only in learning but also, they feel happy through correlating this in everyday lives. In the 21st century, they are inspired to make careers related to science serving mostly the nation.
- Inquire as a scientist- With a profound science, students learn the spirit generated due to scientific inquiry. Besides they can formulate questions and solve them scientifically and can judge the situation logically.
- Innovate using science- Being enthused by science, the student can solve their real-world problems whether they are personal or societal and thus encouraging scientific innovation.

Besides the above three principles, the learning outcomes in science are covered by –

- Core Ideas,
- Practicing,

6.4.4 Values, Ethics with Attitudes. Aims of Primary Science Syllabus

It provides students the opportunities to-

a) Nurture their curiosity about their own environment,
b) Gathering scientific knowledge to understand the world better,
c) Develop skills, habits, and mentality for inquiry relating to science,
d) Apply scientific knowledge to make wise decisions,
e) Praise the scientific endeavor whereas applicable.

Primary Syllabus Framework (See* Table 1*)

It comprises the followings:

- Diversity,
- Cycles, Systems,
- Interactions,
- Energy.

In Table 1, an outline of Science Syllabus in Primary Level 3 to 6 is depicted.

Table 1 An outline of the Science Syllabus in the Primary stage (MOE,2023)

LEVELS	Topics
Primary 3	General characteristics and classification of living and non- living things and their diversity, Diversity of materials, Life cycles in plants and animals, Interactions of Magnetic forces
Primary 4	Parts and various functions of Plant system, Digestive system in Human system, Cycles of water and matter (Matter part), Forms of Light energy and its uses, Forms of Heat energy with its uses
Primary 5	Cycles of Reproduction in plants and animals, Cycles in matter and water (water part), Respiratory and Circulatory system of plants, Respiratory and Circulatory system in Human body, Electrical system
Primary 6	Formation of energy by Photosynthesis and its uses, Conversion of energy, Interaction of various forces (like- Frictional force, Elastic spring force, Gravitational force), Interactions within the environment

6.4.5 Aims of Science Syllabus at Lower Secondary level [Express Course/Normal (Academic)]

These are to-

a) Practice science as a collective human endeavor for better understanding rather than just a fact,
b) Make students scientifically eligible, to take decisions of their own and be liable for their society,
c) Develop strong fundamentals in science that contribute to scientific inquiry and science innovation.

Syllabus framework

This LSSE/N(A) curriculum depends on several themes that are classified in the primary level science syllabus and form the base-stone for upper secondary science. These themes along with topics are discussed in **Table 2.**

Table 2 Overview of the Lower Secondary Science Syllabus [E/N (A)] [Source MOE,2021]

Themes	Topics
Diversity	Exploration of Diversity of Matter through Physical Properties, Chemical Compositions and by Separation Techniques
Models	Light and its Ray Model, Life and its Basic Unit (Models of Cells),Matter and its Particulate Nature (Model of Matter), the Atoms and the Molecules (Model of Matter)
Interactions	Applying Forces and Transferring Energy, Effects of transferring Heat Energy, Chemical Changes, Ecosystems along with its interactions
Systems	Electrical Systems, Digestive system in Human Body, Transport Systems within Living Things, Reproductive System in Human Body

6.4.6 Aims of Upper Secondary Science Syllabus [Normal Technical)]

The aims are to-

a) Build up 21st-century competencies in students,
b) Advise students in gathering not only knowledge, and skills but also values to apply on a daily basis both theoretically and practically,
c) Apply ICT,
d) Make the students prepared for future learning and workforce so that they can develop more useful and relevant skills,
e) Prove themselves as a lifelong learner,
f) Be habituated to safe and ethical practices.

Syllabus Framework

It comprises three interlinking and correlated modules, discussed along with their topics in **Table 3.** In the Upper Secondary level, no particular order in which the module should be taught is shown but the modules should be followed while teaching and learning.

Table 3 Layout of Upper Secondary Syllabus in Science (MOE, 2023)

Module	Topics
Surrounding machines	Energy, wave, electricity, force and its effects
Food matters	Food sources, food safety, food chemistry
Human body concerning health	Being healthy, digestion, breathing, blood circulation

6.4.7 21st -Century Competencies and Scientific Literacy

To thrive in and ensure in a modern globalized world of the 21st century, the framework for students' Competencies and Outcomes identifies the Core Ideas, Social and Emotional competencies. These are referred to as 21st Century Competencies i.e., 21CC.

6.4.8 Improvement of 21CC through science curriculum (MOE, 2023)

- To increase Civic Literacy, Global Awareness, and Cross-cultural skills,
- To incorporate Critical and Inventive thinking,
- To enthuse Communication, Collaboration, and Information Skill.

7. Results and Discussions

Comparative analysis

Similarities

1. Both countries encourage holistic science education which results in the holistic development of children,
2. Both countries accentuate to promote the indigenous property, to provoke nationalism, and preparing lifelong learners. This is the pledge for the 21st century taken by both countries.

Differences

1. India operates (5+3+2+2) education system till date (as the effect of NEP 2020 is not prevailed in all stages) whereas Singapore follows (6+4+2) education system. Maximum variation occurs in the secondary stage.
2. India maintains compulsory education up to class eight (age up to 14 years). Singapore maintains 10 years of compulsory general education. In the primary level, for India duration is 5 years, and for Singapore, it is 6 years.

3. For India a unified curriculum up to the secondary level is followed irrespective of students' diversity, but in Singapore, different secondary schools like- IP, NUS are working depending on the same,
4. India opts for multilingualism for science education, whereas bi-lingual policy is discouraged in Singapore,
5. The advancement of the science curriculum of Singapore is dynamic due to inculcating curiosity and creativity from a very primary level. India has also started encouraging creative and analytical thinking rather than rote learning in a slow but undergoing process.
6. In India, group activities and surveys have been incorporated after 2005 mainly at the secondary level, whereas for Singapore hands-on activities have been encouraged from the primary level after 1979.
7. For India, Laboratory activities are mainly confined to higher secondary level, whereas for upper-primary and secondary level projects are encouraged. For Singapore, hands-on activities are done through the Science garden at the primary level and the Science laboratory at the secondary level.
8. Although having a sound background in science due to a lack of practicality at the secondary level, Indian students have lagged behind in International Tests like- TIMSS, PISA, etc. But Singaporean students participate in practical experiments and problem-solving with more ease and interest at the lower secondary level which helps them to rank extraordinarily high in the international TIMSS, PISA test.
9. Science learning at the primary level appears as a wing of the subject 'Environmental Studies' for India, whereas for Singapore different science syllabus is followed,
10. Science education is appeared as a composite subject at the Indian secondary school level, whereas a more advanced and elaborated syllabus is pursued the same in Singapore.
11. Incorporation of technology in the science curriculum is more in Singapore than that in India.
12. Inter-disciplinary subject change is more feasible in Singapore from a lower secondary stage than that in India.
13. Proposal has been taken recently to form a 'knowledge-based economy' for India, whereas for Singapore this has been continued from 1979 onwards.
14. Values and Ethics are more extensively followed in the science curriculum of Singapore with respect to India.

8. Conclusions

In India, having the second largest population in the world, the percentage of GDP has stayed stagnant at 2.9% since 2019 (retrieved from https://economictimes.indiatimes.com) and is only marginally up from 2.8% in FY2016. Whereas in Singapore, MOE has received the third largest budget for the education sector in FY2023 with a projected total expenditure of USD 10.89 billion (retrieved from https://www.trade.gov/market-intelligence/singapore-budget-2023). This sharp difference in the budget clearly reflects why Singapore makes more approachable opportunities for their students with more ease. With a more flexible, purposeful, activity-based science curriculum Singaporean students set their benchmark high in various international tests, whereas India has yet to reach that goal. With NEP 2020, India has presented a revolutionary change in its school curricular system which will definitely reflects in their students' science achievements. As both countries stand firm to maintain 21st-century goals, it is desirable that they can originate scientifically and technically well-equipped manpower and a better world.

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