

Science curricula for ages 11-12 in developing Asian education systems: A comparative analysis of India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand

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ABSTRACT

This paper presents a qualitative comparative analysis of the intended science curricula for students aged approximately 11-12 in six developing Asian education systems: India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand. Drawing on official curriculum documents, international assessment data used as contextual evidence, and relevant policy and research literature, the study examines historical reform trajectories, curriculum structure and content, prescribed pedagogical approaches, and reported implementation conditions. The findings indicate partial convergence in official curriculum priorities, particularly around scientific literacy, inquiry, scientific processes, competency development, and connections between science and everyday life. These shared priorities are nevertheless organized through distinct national structures, including integrated subjects, standards-based frameworks, spiral progression, and interdisciplinary arrangements. Evidence concerning classroom enactment is more limited, heterogeneous, and unevenly distributed across the six systems. Country-specific studies identify possible implementation constraints related to teacher preparation, instructional resources, assessment, language, and geographical inequality, but the available evidence does not establish that these conditions occur with equal prevalence or intensity in every country. The comparison also identifies distinctive features of the intended curricula, including Indonesia's integrated IPAS model, India's constructivist framework, Malaysia's STEM orientation, Pakistan's effort to establish common standards, the Philippines' spiral progression model, and Thailand's attention to the nature of science. The study concludes that curriculum design and implementation support should be evaluated together through country-specific evidence rather than through uniform cross-national policy prescriptions.

Keywords: science education, developing Asia, comparative curriculum analysis, implementation gap, inquiry-based learning

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INTRODUCTION

Science education at the upper primary and lower secondary levels, particularly for students aged 11-12, occupies a critical position in the educational trajectories of young people across the developing world. It is during this formative stage that students either consolidate the foundations of scientific literacy that will sustain their engagement with science throughout their schooling and beyond or become disengaged from scientific learning in ways that are difficult to reverse (Cheng et al., 2017). In developing Asian countries, where demographic change,

economic transformation, and the imperatives of sustainable development place substantial demands on education systems, the quality of science curricula for this age group is important both for individual learners and for the development of the knowledge and cognitive skills associated with longer-term social and economic development (Hanushek & Woessmann, 2012).

While the performance of Asian education systems such as Singapore, Japan, South Korea, China, and Taiwan has attracted sustained scholarly and policy attention, considerably less comparative research has examined science curricula in the large and rapidly changing

education systems of South and Southeast Asia. In this study, the term “developing Asian education systems” is used as a bounded analytical designation rather than as a claim that the countries constitute a homogeneous economic, cultural, or educational category. It refers here to systems undergoing extensive curriculum modernization while continuing to experience substantial inequalities in institutional capacity, teacher preparation, instructional resources, language provision, and access to consistently high-quality schooling. The term therefore identifies a shared educational-development context while recognizing considerable differences in national income, governance, historical experience, and system performance.

India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand were purposively selected as six contrasting cases within this broader category. Together, they provide coverage of South and Southeast Asia and include highly populous or administratively complex national systems with substantial internal linguistic, socio-economic, regional, or school-sector diversity. All six have introduced national reforms promoting scientific literacy, integrated science, inquiry-oriented learning, competency development, or STEM education, while differing in curriculum organization, governance arrangements, language policy, colonial history, and participation in international assessments. Their comparative coherence consequently rests not on an assumption of uniformity but on a common analytical problem: how ambitious national science-curriculum reforms are interpreted and supported under conditions of unequal implementation capacity (Panth & Maclean, 2020; Symaco & Hayden, 2024).

The selection is not intended to represent every education system that could reasonably be described as developing and Asian. Vietnam and Sri Lanka, among other countries, are relevant potential cases, but they were not treated as part of the present six-country comparison. Vietnam would provide a particularly informative contrast because its international assessment trajectory differs from that of most countries examined here, while Sri Lanka represents a smaller system with a distinctive educational and institutional history. Their exclusion therefore reflects the bounded, purposive design of the study rather than a judgment that they fall outside the broader category. Extending the analytical framework to these and other Asian systems would be a valuable direction for subsequent comparative research.

International large-scale assessment results provide relevant background to the reform context of the six education systems, but they cannot be treated as direct measures of the quality or effectiveness of science curricula for students aged 11-12. PISA assesses 15-year-old students, who are generally several years beyond the age group examined in this study, whereas TIMSS assesses students in the fourth and eighth grades. TIMSS therefore provides evidence from grade levels that may precede or follow the focal age group, depending on the organization of each national system, rather than from a uniform sample of 11-

and 12-year-olds. Moreover, the six countries have not participated in the same assessment cycles, grades, or programs. Consequently, the results are used here only to describe the broader system-level context in which curriculum reforms have developed and not to infer a direct causal relationship between a particular curriculum and student achievement at ages 11-12.

Within these limitations, PISA 2022 reported mean science scores of 383 for Indonesia, 409 for Thailand, 404 for Malaysia, and 356 for the Philippines, all below the OECD (2023) average. India's participation has been limited, while Pakistan has not participated in PISA. Participation in TIMSS has also varied across the six systems, with countries entering different cycles and grade-level assessments (von Davier et al., 2024). These differences prevent straightforward cross-national conclusions about the effectiveness of the focal curricula. Nevertheless, the assessment results have contributed to wider national debates about science learning and have formed part of the policy environment in which recent curriculum and assessment reforms have been introduced (Vincent-Lancrin et al., 2019; World Bank, 2018).

Despite the growing recognition of the need for reform, the comparative education literature on science curricula for the 11-12 age group in developing Asian countries remains remarkably sparse. Existing studies have tended to focus on individual countries in isolation, on particular dimensions of science education such as teacher quality or assessment, or on limited cross-national comparisons of selected Southeast Asian science curricula, such as Indonesia, Vietnam, and Thailand, without providing an integrated comparative analysis of the curriculum structures, content frameworks, pedagogical approaches, and historical reform trajectories that shape science education for early adolescents across a wider group of developing Asian systems (El Islami et al., 2022). Furthermore, much of the available literature has been framed in deficit terms, emphasizing what developing Asian systems lack in comparison with their higher-performing counterparts, rather than examining the distinctive reform initiatives, contextual adaptations, and policy responses that these countries have developed in response to their particular educational circumstances (Panth & Maclean, 2020).

The present paper seeks to address this gap by offering a comprehensive comparative analysis of the science curricula for students aged 11-12 in six developing Asian education systems: India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand. This focus builds on recent comparative curriculum research on science education for the same age group, including work on science curricula for ages 11-12 across the European Union (Tsiouri et al., 2024). It also draws on the broader discussion of physics curricula and student understanding in European high schools (Kotsis, 2024b), while extending the analytical lens to developing Asian systems where implementation conditions, demographic pressures, and resource

constraints are substantially different (Kotsis et al., 2025b). The analysis is organized around four interconnected dimensions: the historical context and evolution of science education in each system, encompassing the colonial legacies, post-independence reforms, and contemporary policy developments that have shaped current curricula; the structure and content of the science curriculum, including the organization of knowledge domains, the balance between integrated and discipline-based approaches, and the articulation of competency goals; the teaching methods and pedagogical approaches employed in science classrooms, with attention to the gap between inquiry-oriented policy rhetoric and the realities of classroom practice; and the implications of cross-national patterns for curriculum development and educational policy in developing Asian contexts. The rationale for selecting these six countries rests on their collective demographic significance, their shared yet distinct reform trajectories, and their participation, or anticipated participation, in international assessment programs that provide a common benchmarking framework (Symaco & Hayden, 2024; von Davier et al., 2024).

A necessary clarification concerns the age range examined in the study. Although the article focuses on students aged 11-12, this age group does not correspond to exactly the same grade level in all six education systems. In some countries, it falls mainly within the final years of primary education, while in others it overlaps with the transition to lower secondary education or the beginning of junior secondary schooling. For this reason, the study treats ages 11-12 as a transitional curriculum stage between upper primary and lower secondary science education rather than as a strictly identical grade level across all countries. This approach allows the comparison to remain focused on a common developmental stage while also respecting national differences in school structure, grade organization, and curriculum sequencing.

The study contributes to comparative science education research by applying a common analytical framework to six Asian education systems that are rarely examined together. It compares their historical reform trajectories, formal curriculum structures, content organization, prescribed pedagogical approaches, and reported implementation conditions. The comparison does not assume that the six systems are homogeneous or that their classroom practices can be established directly from policy documents and secondary literature. Instead, it examines the extent to which the available evidence supports similarities and differences in curriculum intentions and in the conditions reported to affect their implementation.

Accordingly, the study addresses the following research questions:

1. How have historical reform trajectories shaped the structure and content of science curricula for students aged approximately 11-12 in India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand?
2. What pedagogical approaches and science-learning competencies are prescribed in the official curricula, and what conditions affecting their implementation are reported in the available policy and research literature?
3. What similarities, differences, and recurring patterns emerge across the six systems, and what are the limits of the available evidence for comparing intended curricula with reported classroom implementation?

The following section explains the methodological procedures and analytical framework used to address these questions.

METHODOLOGY AND ANALYTICAL FRAMEWORK

This study adopts a qualitative comparative curriculum analysis of science education for students aged approximately 11-12 in six developing Asian education systems: India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand. The selection of these countries was based on four criteria. First, they represent large and demographically significant education systems in developing Asia. Second, they share common structural challenges, including urban-rural disparities, shortages of qualified science teachers, resource limitations, and examination-oriented traditions. Third, they have all undertaken major curriculum reforms aimed at strengthening inquiry-based learning, scientific literacy, competency development, and STEM-oriented education. Fourth, several of them participate, or have participated, in international assessment programs such as PISA and TIMSS, allowing their curriculum reforms to be considered in relation to broader evidence on science learning outcomes.

Document Corpus and Search Procedure

The study employed a structured qualitative comparative document analysis rather than a systematic review or a direct investigation of classroom practice. The documentary corpus was organized into three evidence categories. The first comprised official national curriculum frameworks (NCFs), science curriculum guides, grade- or phase-specific learning standards, and relevant education-policy documents applicable to students aged approximately 11-12. The second included reports from international and national organizations concerning educational assessment, teacher provision, school resources, and system-level reform. The third comprised peer-reviewed empirical and comparative studies addressing science curricula, pedagogy, assessment, teacher preparation, language of instruction, and implementation conditions in one or more of the six countries.

Documents were identified between November 2025 and May 2026 through a purposive, targeted search rather

than an exhaustive systematic-review procedure. Official curriculum and policy documents were located through the websites and document repositories of the six national ministries of education and their curriculum authorities. Reports providing broader system-level evidence were retrieved from the repositories of the OECD, the International Association for the Evaluation of Educational Achievement, UNESCO, and the World Bank. Peer-reviewed studies were identified through targeted Google Scholar searches and backward reference searching. Search combinations included the country name together with terms such as “science curriculum,” “science education,” “primary science,” “lower secondary science,” “Grade 5,” “Grade 6,” “Grade 7,” “ages 11-12,” “inquiry-based learning,” “teacher preparation,” “laboratory resources,” “assessment,” and “curriculum implementation.” Because the purpose was to assemble an authoritative and analytically relevant corpus rather than to conduct a systematic review, the search was not intended to retrieve every publication concerning science education in the six countries.

Documents were included when they:

- (a) addressed at least one of the six focal education systems;
- (b) concerned the curriculum stage corresponding approximately to ages 11-12 or provided directly relevant system-level evidence;
- (c) contained evidence about curriculum structure, science content, prescribed pedagogy, assessment, teacher preparation, language policy, resources, or implementation conditions; and
- (d) were official documents, reports from established national or international organizations, or peer-reviewed academic publications.

Documents were excluded when they:

- (a) concerned only higher education or early childhood education;
- (b) discussed STEM education or educational technology without a clear connection to school science;
- (c) made regional claims without identifiable country-level evidence;
- (d) duplicated a more recent or authoritative version of the same document; or
- (e) provided commentary without a transparent empirical or documentary basis.

English-language versions of official documents were used wherever they were available. For selected official curriculum documents available only in a national language, ChatGPT-assisted translation was used solely as a linguistic aid. Key curriculum terms and relevant passages were checked against available official English-language materials, ministry summaries, and English-language country-specific research. AI-generated translations were not treated as independent evidence and were not used to

establish claims without support from the original document or an additional authoritative source. Because the study employed purposive document selection rather than a systematic-review design, no PRISMA-style screening count was generated.

Table 1 identifies the core official documents used to establish the intended science curriculum and the relevant reform context in each country. It distinguishes currently applicable documents from legacy, transitional, or draft materials so that differences in their evidential status are explicit. Secondary empirical studies and international reports were used separately to examine reported implementation conditions and are listed in the References.

Evidence Extraction and Coding

A standardized extraction matrix was developed and applied to all six countries. For each document, the matrix recorded the issuing body or author, publication year and version, country, language, relevant age or grade, document type, type of evidence, and findings related to four predefined analytical dimensions: historical reform trajectory; curriculum structure and content; prescribed pedagogical approaches and competencies; and reported implementation conditions. The final dimension was divided into teacher preparation, professional development, laboratory and instructional resources, assessment pressure, language of instruction, class size, digital access, and urban-rural or socio-economic inequality. Additional subthemes were added when they appeared repeatedly across the corpus.

Coding proceeded in two stages. First, official curriculum and policy documents were coded to identify evidence concerning the intended curriculum, including prescribed content, learning outcomes, competencies, pedagogical expectations, and assessment principles. Second, empirical studies and institutional reports were coded separately for evidence concerning reported implementation conditions. Statements about classroom practice were retained only when supported by country-specific empirical research or clearly documented national evidence. Generic regional or international publications were used for conceptual interpretation or broader contextualization but not as the sole support for claims about an individual country.

Quality Appraisal and Consistency Checking

The methodological quality and relevance of each source were appraised according to its institutional or publication origin, direct relevance to the focal age or grade, national specificity, publication date, methodological transparency, and correspondence with the claim for which it was used. Current official curriculum documents were treated as the primary evidence for the intended curriculum. Peer-reviewed country-specific empirical studies were prioritized for reported classroom and implementation conditions, while international assessment and development reports were used mainly to establish the broader system context. When sources differed, greater

Table 1. Core official documents used in the comparative curriculum analysis

Country	Official document and version	Relevant stage	Function and evidential status
India	National Council of Educational Research and Training (NCERT), NCF 2005; Ministry of Education, National Education Policy 2020; NCERT, NCF for school education 2023 (English versions).	Classes VI–VIII; transition to the middle stage	NCF 2005 and its associated science materials establish the earlier constructivist and integrated-science orientation. NEP 2020 and NCF-SE 2023 identify the direction of current reform. The newer framework is treated as transitional where implementation is incomplete.
Indonesia	Badan Standar, Kurikulum, dan Asesmen Pendidikan, Capaian Pembelajaran Mata Pelajaran Ilmu Pengetahuan Alam dan Sosial (IPAS), Fase A–C, and Capaian Pembelajaran Mata Pelajaran Ilmu Pengetahuan Alam (IPA), Fase D, Kurikulum Merdeka, issued under Decision of the Head of BSKAP No. 046/H/KR/2025 (Indonesian-language versions, accessed May 2026).	Fase C, primary level; phase D, grades 7–9	Used to identify the integration of natural and social science in IPAS, the organization of junior-secondary science, phase-based learning outcomes, inquiry competencies, and project-oriented expectations.
Malaysia	Curriculum Development Division, Ministry of Education, Dokumen Standard Kurikulum dan Pentaksiran: KSSR (Semakan 2017) Sains Tahun 5 and Sains Tahun 6; relevant KSSM lower-secondary science documentation; Malaysia Education Blueprint 2013–2025 (Malay and available English versions).	Years 5–6 and transition to form 1	Used to identify content and learning standards, science-process skills, performance expectations, higher-order thinking, STEM priorities, and continuity between primary and lower-secondary science.
Pakistan	National Curriculum Council, SNC: General Science, Grades IV–V (2020); SNC: General Science, Grades VI–VIII—Zero Draft (2020), English versions.	Grades IV–V and proposed grades VI–VIII framework	The Grades IV–V document is treated as an official statement of learning standards. The Grades VI–VIII document is used only to identify the proposed reform direction because it is explicitly a Zero Draft; it is not evidence of uniform national implementation.
Philippines	Department of Education, K to 12 Science Curriculum Guide, Grades 3–10 (August 2016); Revised K to 10/MATATAG Science Curriculum Guide and phase-one Grade 4 and Grade 7 materials (English versions).	Grades 6–7; transition from upper primary to lower secondary	The 2016 guide establishes the spiral-progression model examined in the earlier literature. MATATAG materials identify the subsequent curriculum transition and are not treated as evidence that the revised framework has been implemented uniformly across all focal grades.
Thailand	Ministry of Education, Basic Education Core Curriculum B.E. 2551 (A.D. 2008); Institute for the Promotion of Teaching Science and Technology, Learning Standards and Indicators for Science and Technology, revised B.E. 2560 (A.D. 2017) (Thai documents and official English core-curriculum version).	Grades 4–6 and grades 7–9	Used to identify curriculum strands, grade-cluster indicators, science and technology standards, process skills, and the transition between upper-primary and lower-secondary science.

Note. The table reports the core national documents used to analyze the intended curriculum. Official documents were treated as evidence of prescribed content, competencies, and pedagogical expectations, not as evidence that these expectations were enacted uniformly in classrooms. Draft and transitional documents were interpreted according to their stated status. International assessment reports, institutional studies, and peer-reviewed empirical publications were used only for system context and reported implementation conditions (Sources: Official documents and repositories of NCERT and the Ministry of Education (India); the national curriculum authority (Indonesia); the Curriculum Development Division, Ministry of Education (Malaysia); the National Curriculum Council (Pakistan); the Department of Education (Philippines); and the Ministry of Education, OBEC, and IPST (Thailand). Full bibliographic entries are in the manuscript reference list).

weight was assigned to the more recent, directly relevant, and methodologically transparent evidence. Contradictory findings or incomplete evidence were retained as qualifications rather than resolved through unsupported generalization.

The document corpus was coded by one researcher using the predefined analytical framework and extraction matrix. To strengthen intra-coder consistency, the researcher repeated the coding after an interval and compared the two coding rounds. Differences in code assignment or interpretation were resolved by returning to the complete original documents and reassessing the relevant evidence. An audit trail was maintained to record source-selection decisions, changes to the coding framework, revised code assignments, and the evidential basis of the cross-national interpretations. Because the analysis was conducted by one researcher, no inter-rater reliability coefficient was calculated.

Following the consistency check, the completed country matrices were compared to identify recurring patterns, national differences, and areas in which the available evidence was incomplete or unequal. The analysis consistently distinguishes among the intended curriculum, documented through official curriculum and policy texts; reported implementation conditions, identified through empirical studies and institutional reports; and the enacted curriculum, which cannot be established directly without comparable classroom observations, interviews, or other primary data. The findings should therefore be interpreted as evidence about curriculum intentions and reported conditions affecting implementation, not as direct or nationally representative evidence of classroom enactment.

The comparison is organized around four analytical dimensions. The first dimension is the historical evolution of science education, including colonial legacies, post-independence nation-building, and recent curriculum

reforms. The second dimension is curriculum structure and content, including the organization of science as an integrated or discipline-based subject, the sequencing of science domains, and the emphasis placed on scientific knowledge, process skills, and competencies. The third dimension is teaching methods and pedagogical approaches, with particular attention to inquiry-based learning, student-centered instruction, laboratory and hands-on activities, and the persistence of teacher-centered and examination-oriented practices. The fourth dimension concerns cross-national patterns and policy implications, especially the implementation gap between intended and enacted curriculum.

A further methodological consideration concerns the age group under study. Although the article focuses on students aged 11-12, this age range does not correspond to exactly the same grade level in all six education systems. In some countries it falls mainly within upper primary education, while in others it overlaps with the transition to lower secondary education. For this reason, the analysis focuses on the curriculum stage broadly equivalent to the transition from upper primary to lower secondary science education. This approach allows meaningful comparison while recognizing the differences in national grade structures, curriculum cycles, and school organization.

The paper proceeds with an overview of the historical context of science education across the six systems, followed by a comparative analysis of curriculum structure and content, an examination of teaching methods and pedagogical approaches, a discussion of the findings, and concluding remarks with recommendations for future research and policy.

HISTORICAL CONTEXT OF SCIENCE EDUCATION

The historical development of science education in India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand has been shaped by colonial legacies, post-independence nation-building, and successive curriculum reforms linked to economic development, democratization, and globalization. Although their historical trajectories differ, Dutch colonial rule in Indonesia, British influence in Malaysia, India, and Pakistan, Spanish and American rule in the Philippines, and selective Western borrowing in Thailand, all six systems developed modern school science within broader projects of state formation and educational expansion. These historical foundations remain important for understanding the present structure of science curricula and the persistent implementation challenges that affect science education for students aged 11-12 (Panth & Maclean, 2020; Symaco & Hayden, 2024).

In Indonesia, the modern education system traces its origins to the Dutch colonial period, during which formal schooling was restricted to a small elite and oriented toward the production of administrative personnel for the

colonial government. Science education, to the extent that it existed, was confined to European-model schools and was taught in Dutch, rendering it inaccessible to the vast majority of the indigenous population. Following independence in 1945, Indonesia restructured its education system by replacing the colonial dual-track model with a unified national system using Bahasa Indonesia as the medium of instruction. Since then, successive curriculum reforms have reflected changing political, social, and developmental priorities. Kurikulum 2013 marked an important shift from rote memorization toward competency-based learning and integrated science at the junior secondary level. More recently, Kurikulum Merdeka, launched in 2022 as part of the broader Merdeka Belajar reform program, has expanded school and teacher autonomy, emphasized project-based learning and student agency, and linked science education to the development of the Pancasila student profile (OECD, 2023; World Bank, 2020).

Malaysia's science education system is rooted in the British colonial framework that established English-medium schools alongside vernacular schools in Malay, Chinese, and Tamil. Following independence in 1957 and the formation of Malaysia in 1963, education reform focused on national integration, the promotion of Bahasa Melayu, and the expansion of access to schooling as part of economic development. The Razak report of 1956 and the Rahman Talib report of 1960 helped establish a centralized national curriculum in which science became a core subject. Later reforms were strongly shaped by debates over the language of science instruction, especially the introduction of the teaching of mathematics and science in English policy in 2003 and its replacement by the dual language program after 2012. The current Kurikulum Standard Sekolah Menengah, implemented progressively from 2017, establishes scientific literacy, higher-order thinking skills (HOTS), and STEM-related learning as formal policy priorities. The Malaysia education blueprint 2013-2025 similarly identifies teacher quality and educational equity as system-level reform priorities, while PISA 2022 provides broader evidence on student outcomes. These policy and assessment sources describe the national reform context; they do not, by themselves, establish how consistently the curriculum is enacted across Malaysian science classrooms (Ministry of Education Malaysia, 2013; OECD, 2023).

In India, the evolution of science education reflects the country's vast scale, linguistic diversity, and the complex interplay between central and state-level governance of education. The British colonial education system, established through a series of reforms beginning with Lord Macaulay's minute of 1835, introduced Western-model science instruction primarily through English-medium institutions serving the colonial administrative elite. After independence in 1947, India expanded and democratized its education system through successive national commissions and policy frameworks, including the Kothari Commission, the national policy on education, and the NCF of 2005. The NCF 2005 marked a major shift towards inquiry-based and

constructivist science education, emphasizing connections with learners' everyday experiences and local environments (National Council of Educational Research and Training, 2005). The national education policy 2020 renewed this reform agenda by introducing a 5 + 3 + 3 + 4 curricular structure and promoting experiential, competency-based, and inquiry-oriented learning (Ministry of Education, Government of India, 2020). These national documents establish the intended direction of curriculum reform but do not demonstrate uniform implementation across India's diverse states, school sectors, and local contexts.

Pakistan's science education system has been shaped by British colonial legacies, nation-building after the partition of 1947, limited public investment, and deep inequalities between provinces, school sectors, and urban and rural areas. Since the devolution of education governance under the Eighteenth Constitutional Amendment of 2010, curriculum development has been highly fragmented across provinces and territories. The single national curriculum (SNC) represents an attempt to establish common learning standards for core subjects, including science, across Pakistan's education system. Its science documents emphasize scientific literacy, knowledge from the life, physical, and earth sciences, and the development of inquiry and scientific process skills (National Curriculum Council, 2020a, 2020b). Curriculum reform is also closely connected to textbook development because textbooks may communicate national, cultural, social, and environmental meanings in addition to disciplinary content (Shah, 2023; Yasmin et al., 2026). These sources document curriculum intentions and textbook characteristics but do not establish uniform classroom implementation across Pakistan's provinces and school sectors. Moreover, the absence of Pakistani PISA and TIMSS results limits international outcome comparisons; it should not be presented as a constraint on curriculum implementation.

Thailand occupies a distinctive position among the six countries because it was never formally colonized by a European power, although its education system was modernized through selective borrowing from Western models. Science became part of the national curriculum during the 20th century and has remained closely linked to the policy goal of strengthening scientific literacy (Yuenyong & Narjaikaew, 2009). The basic education core curriculum B.E. 2551 (2008) established science as a core learning area encompassing the physical sciences, life sciences, earth and space sciences, scientific processes, and scientific attitudes. Its revised science standards continue to promote inquiry, evidence-based reasoning, and the application of scientific knowledge (Institute for the Promotion of Teaching Science and Technology, 2017). These official documents establish Thailand's intended curriculum; they do not provide direct evidence that teacher-centered instruction, teacher shortages, resource disparities, or examination pressures characterize science classrooms nationwide. Such conditions should therefore be reported only where they are supported by Thai

empirical studies and should not be inferred from OECD achievement data or general World Bank reports.

The Philippines' education system reflects both Spanish and American colonial influence, with the American period being especially important for the development of English-medium public schooling and the incorporation of science as a core subject. After independence in 1946, successive reforms culminated in the K to 12 program, enacted in 2013, which extended compulsory education and aligned schooling more closely with national development and ASEAN regional goals (Limjap et al., 2017). The K to 12 science curriculum guide organized science around a spiral progression model in which concepts from the life sciences, physical sciences, and earth and space sciences are revisited with increasing depth across successive grades (Department of Education, 2016). The more recent MATATAG curriculum revises the science standards for grade 4 and grade 7 while retaining an emphasis on progressive conceptual development and scientific inquiry (Department of Education, 2023). PISA 2022 indicates difficulties in science performance among Filipino 15-year-olds, but these results do not directly demonstrate curriculum implementation conditions for students aged 11-12 or identify teacher shortages, class size, and laboratory provision as their causes (OECD, 2023).

The six systems display a degree of convergence at the level of intended curriculum: their official frameworks emphasize scientific literacy, inquiry, competency development, and the application of science to everyday contexts, although the terminology and emphasis differ among countries. Evidence concerning curriculum enactment is less consistent and is unevenly distributed across the six cases. Teacher preparation, instructional resources, assessment pressures, language, and geographical inequality emerge as recurrent implementation considerations, but they are not documented with equal strength in every system. Accordingly, the implementation gap is used here as a comparative analytical theme rather than presented as an identical or directly established condition across all six countries.

CURRICULUM STRUCTURE AND CONTENT

The science curricula for students aged 11-12 in India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand exhibit considerable diversity in their structural organization, content coverage, and the degree to which recent reform aspirations have been translated into operational curriculum documents. While all six countries have adopted national or centrally guided curriculum frameworks that prescribe science as a compulsory subject during the upper primary and lower secondary years, the specific ways in which content is selected, organized, and sequenced reflect the distinctive educational traditions, governance structures, and reform priorities of each

system. A comparative examination of curriculum structure and content across the six systems reveals both shared features and significant divergences that illuminate the particular challenges and opportunities facing science education in developing Asia (Symaco & Hayden, 2024; World Bank, 2020).

In Indonesia, the science curriculum for students aged 11-12 has undergone a significant structural transformation under the Kurikulum Merdeka, which has been progressively implemented since 2022. At the elementary school level (Sekolah Dasar), a notable innovation is the merger of natural sciences (ilmu pengetahuan alam [IPA]) and social sciences (ilmu pengetahuan sosial [IPS]) into a single integrated subject known as ilmu pengetahuan alam dan sosial (IPAS), which aims to enable students to understand natural and social phenomena holistically rather than as separate disciplinary domains. This integration, while conceptually ambitious, has posed significant challenges for teachers trained in either science or social studies but not both. At the junior secondary level (Sekolah Menengah Pertama, grade 7-grade 9), science continues to be taught as an integrated subject (IPA) encompassing content from physics, chemistry, biology, and earth and space science. This integrated organization is consistent with comparative evidence showing that Indonesia, Vietnam, and Thailand structure school science curricula around broad scientific domains while differing in sequencing, emphasis, and implementation priorities (El Islami et al., 2022). Under the Kurikulum Merdeka, the curriculum is organized around Learning Achievements (Capaian Pembelajaran) defined in phases rather than year-by-year, granting schools and teachers considerable flexibility in sequencing and pacing content. The grade 7 IPA curriculum, for instance, covers topics including the nature of science and the scientific method, substances and their changes, temperature, heat, and expansion, motion and force, classification of living things, ecology and biodiversity of Indonesia, and earth and the solar system. A distinctive feature of the Kurikulum Merdeka is the *Projek Penguatan Profil Pelajar Pancasila* (Project for Strengthening the Pancasila Student Profile), which provides opportunities for cross-curricular projects connected to themes such as sustainable lifestyles and local wisdom, thereby linking curriculum learning with broader student-development goals (Badan Standar, Kurikulum, dan Asesmen Pendidikan, n.d.-b). In this direction, recent work on green chemistry and cultural wisdom suggests that connecting science learning with sustainability and culturally grounded knowledge can provide a meaningful pathway for improving students' scientific literacy (Mashami, 2025).

Malaysia's science curriculum for the 11-12 age group is governed by the Kurikulum Standard Sekolah Rendah (KSSR) for primary schools and the Kurikulum Standard Sekolah Menengah (KSSM) for secondary schools. At the upper primary level (year 5 and year 6), science is taught as a single integrated subject organized around broad themes including life science, physical science, materials science, earth and space science, and technology and sustainable

living. The curriculum emphasizes the development of scientific skills, both manipulative skills (using and handling scientific apparatus) and science process skills (observing, classifying, measuring, inferring, predicting, communicating, and experimenting), alongside the acquisition of scientific knowledge and positive scientific attitudes and values. At the lower secondary level (form 1, corresponding to approximately age 13), the KSSM science curriculum extends these themes with greater depth and introduces more explicit emphasis on HOTS, STEM integration, and the application of science to everyday life. A persistent structural challenge in Malaysia's science curriculum has been the medium-of-instruction policy. Following the reversal of the teaching of mathematics and science in English (PPSMI) policy in 2012, science may be taught in either Bahasa Melayu or English under the dual language program, but the inconsistency in language of instruction across schools has created disparities in students' access to scientific terminology and the international scientific literature. The Malaysian government has also placed increasing emphasis on STEM education through the Malaysia Education Blueprint 2013-2025, which identifies increased participation in science and technology pathways and improvements in the quality of STEM teaching and learning as national policy priorities (Ministry of Education Malaysia, 2013). However, the Blueprint establishes the intended policy direction and does not, by itself, demonstrate the extent or consistency of its implementation in Malaysian classrooms.

India's science curriculum for the 11-12 age group is shaped by the NCF 2005, which continues to serve as the principal policy document guiding curriculum design pending the full implementation of the new framework under the national education policy 2020. The NCF 2005, operationalized through the NCERT textbooks used in schools affiliated with the Central Board of Secondary Education (CBSE), organizes science education at the upper primary level (class VI-class VIII) around three broad domains: Food, Materials, and the World of the Living; Moving Things, People, and Ideas; and How Things Work, with additional themes related to natural phenomena and natural resources. This thematic structure was designed to move away from the compartmentalization of physics, chemistry, and biology that had characterized earlier curricula and to promote an integrated understanding of the natural world grounded in everyday experience and local context. At the upper primary stage, science is taught as a general science subject that draws on all three traditional disciplines, with the expectation that teachers will employ activity-based and inquiry-oriented pedagogy. The NCF 2005 explicitly articulated a constructivist pedagogical philosophy, advocating for learning by doing, the integration of local knowledge and environment, and the cultivation of scientific temper, a constitutional value in India. However, the enormous diversity of the Indian education system, encompassing CBSE, state boards, ICSE, and other affiliating bodies, means that the actual curriculum experienced by students varies significantly

across states and school types. The NCF for school education 2023, developed within the policy direction established by the national education policy 2020, adopts the 5 + 3 + 3 + 4 curricular structure and advances competency-based learning, inquiry, experimentation, and interdisciplinary connections in science education. Because the reviewed evidence does not establish the extent of its enactment across India's diverse states, school boards, and school sectors, the framework is treated here as evidence of intended curriculum reform rather than uniform nationwide implementation (Ministry of Education, Government of India, 2020; National Council of Educational Research and Training, 2023).

Pakistan's science curriculum for the 11-12 age group is undergoing a major restructuring under the SNC, the first phase of which was implemented in 2021 for grade 1-grade 5, with subsequent phases extending to higher grades. For students in the upper primary grades (grade 4-grade 5), the SNC prescribes a general science curriculum organized around four core domains: life science, physical science, earth and space science, and environmental science, with an additional strand on the nature of science and scientific inquiry. The curriculum articulates student learning outcomes for each grade and domain, specifying the knowledge, skills, and attitudes that students are expected to demonstrate. At the lower secondary level (grade 6-grade 8), science is typically taught as a single integrated subject in most provinces, covering topics across biology, chemistry, physics, and earth science, although the depth and quality of coverage vary enormously across the country's diverse schooling landscape, from well-resourced urban private schools to under-resourced rural government schools and the parallel madrasa system. A distinctive challenge in Pakistan is the extreme fragmentation of the education system following the devolution of education governance to provinces under the Eighteenth Constitutional Amendment, which has meant that the SNC must be adopted and adapted separately by each province and territory, leading to uneven implementation. The language of instruction adds a further layer of complexity, with science taught in Urdu, English, or regional languages depending on the province and school type. The reviewed literature identifies this multilingual context as a relevant implementation consideration, but it does not provide nationally representative evidence demonstrating its effects on students' acquisition of scientific terminology and concepts (Symaco & Hayden, 2024).

Thailand's science curriculum for students aged 11-12 is governed by the basic education core curriculum of 2008, which organizes learning into eight subject groups, with science designated as one of the core learning areas. The science curriculum is structured around eight content standards spanning four broad strands: living things and processes of life, life and the environment, substances and properties of substances, and force and motion, with additional strands covering energy, earth processes, astronomy and space, and the nature of science and technology. For each strand, the curriculum specifies

learning indicators that define the expected learning outcomes for each grade cluster (grade 4-grade 6 and grade 7-grade 9, corresponding to the age group under study). At the upper primary level, science is taught as an integrated subject, while at the lower secondary level, it may be taught either as integrated science or as separate disciplines depending on school-level decisions. The Thai curriculum explicitly articulates both content knowledge and science process skill goals, including the skills of observation, measurement, classification, communication, prediction, inference, hypothesis formulation, variable identification, experimental design, data interpretation, and conclusion drawing. A distinctive feature of Thailand's science curriculum is its explicit attention to the nature of science and technology, including the processes, limitations, and social applications of scientific knowledge (Institute for the Promotion of Teaching Science and Technology, 2017). This feature represents an intended curriculum objective. The evidence included in the present review is insufficient to establish that textbook-based direct instruction and rote memorization constitute the dominant pedagogy across Thai science classrooms, particularly in rural and provincial areas. OECD assessment results and general World Bank reports are therefore not used as direct evidence of nationwide classroom practice.

The Philippines' science curriculum for the 11-12 age group is defined by the K to 12 science curriculum guide, which organizes science education around a spiral progression approach from grade 3 through grade 10. At the upper elementary level (grade 4-grade 6), science is taught as a general science subject, with content drawn from the four major domains of earth and space, living things and their environment, force, motion, and energy, and matter. At the lower secondary level (grade 7-grade 10), science continues to be taught as an integrated subject, but the content is organized quarterly, with each quarter devoted to one of the four domains in a rotating pattern across the four years. For example, a grade 7 student studies earth and space in the first quarter, living things and their environment in the second, force, motion, and energy in the third, and matter in the fourth, with each domain revisited at a higher level of complexity in subsequent grades. This spiral progression model is designed to ensure that students encounter all major science domains each year and that their understanding deepens progressively over time. However, studies of the Philippine K to 12 science curriculum indicate that students' learning progress within the spiral progression model depends on several implementation conditions, including curriculum alignment, continuity across strands, instructional quality, students' prior knowledge, and the availability of appropriate learning support (Camara, 2020; Garcia, 2021). This concern is reinforced by analyses comparing the Philippine K to 12 mathematics and science curriculum with the TIMSS 2015 assessment framework, which suggest that curriculum alignment with international assessment expectations remains an important issue for science curriculum development (Balagtas et al., 2019). In addition,

recent comparative work on the Philippines and Japan has shown that the biology curriculum can be examined not only in terms of content sequencing but also in relation to the epistemic goals and practices through which students are expected to engage with scientific knowledge (Errabo et al., 2024). The curriculum specifies three broad areas of competence: understanding and applying scientific knowledge, performing scientific processes and skills, and developing scientific attitudes and values (Department of Education, 2016). Philippine studies indicate that learning within the spiral-progression curriculum is influenced by factors such as curriculum alignment, continuity between strands, prior knowledge, instructional quality, and learning support (Garcia, 2021). However, the sources included in this review do not provide nationally representative evidence concerning class size, shortages of specialist science teachers, laboratory availability, or the effects of English-medium science instruction on students aged 11-12. These conditions are therefore not presented as established nationwide barriers.

A comparative examination of curriculum structure and content across the six systems reveals several shared patterns and important divergences. Previous comparative work on ASEAN and related science curricula has also shown that specific content areas, such as animal- and plant-related topics, are distributed differently across Indonesia, Malaysia, Thailand, the Philippines, Singapore, and other comparative cases, reflecting both common regional curriculum concerns and national differences in emphasis (Ilma et al., 2022; Sariyah & Widowati, 2022). The comparison identifies partial convergence in the organization and stated priorities of the intended curricula. Each system provides science education through an integrated, thematic, standards-based, or spiral arrangement during at least part of the upper-primary to lower-secondary transition. However, these arrangements are not equivalent. Indonesia's IPAS combines natural and social sciences at the elementary level, Malaysia organizes science around broad thematic domains, India employs NCF-based domains, Pakistan uses strands within the SNC, Thailand specifies content standards, and the Philippines follows a spiral progression model. Across these different structures, the official documents commonly emphasize scientific literacy, science-process skills, inquiry, and the application of knowledge alongside content learning. This shared curriculum language should not be interpreted as evidence of identical curriculum design, comparable instructional provision, or alignment with the curricula of higher-performing Asian systems. Evidence concerning curriculum enactment is substantially more limited and uneven. Country-specific studies report implementation considerations related to teacher preparation, instructional resources, assessment, language, and geographical inequality, but their combination, strength, and evidential support differ among the six systems. The analysis therefore compares the implementation conditions documented for each country without assuming that every reported

constraint operates nationally or with similar prevalence across the six education systems.

To make these cross-national patterns more visible, **Table 2** summarizes the main features of curriculum structure and content across the six education systems. **Table 2** shows that the countries differ in curriculum terminology, grade organization, and sequencing models, but share a common policy orientation toward integrated science, scientific literacy, inquiry skills, and competency-based learning.

TEACHING METHODS AND PEDAGOGICAL APPROACHES

The official curriculum frameworks reviewed for the six countries promote to differing degrees, inquiry, student participation, practical activity, scientific reasoning, and the development of HOTS. Evidence concerning enacted pedagogy is considerably more fragmented. Country-specific studies report teacher-centered, textbook-based, or examination-oriented instruction in particular settings, but the available corpus does not support the conclusion that these approaches prevail in the majority of science classrooms across all six systems. This section therefore distinguishes prescribed pedagogical approaches from context-specific evidence of classroom practice and avoids treating patterns observed in selected schools or regions as nationally representative findings.

In Indonesia, the Kurikulum Merdeka has introduced a pedagogical vision that foregrounds differentiated learning, project-based instruction, and the active cultivation of the Pancasila student profile's six dimensions: faith and devotion to God, global diversity, mutual cooperation, independence, critical reasoning, and creativity. Teachers are expected to design learning experiences that engage students in authentic inquiry, collaborative problem-solving, and cross-curricular projects that connect science to real-world issues and local contexts. The integration of science and social studies into the IPAS subject at the elementary level further demands a pedagogical approach that transcends traditional disciplinary boundaries. Indonesian studies conducted in particular institutional and classroom settings identify difficulties in translating curriculum principles into practice. These include challenges in designing inquiry-oriented lessons and managing scientific-approach activities (Nasir et al., 2020), developing teachers' understanding of integrated STEM education and providing suitable facilities (Arlinwibowo et al., 2023), and aligning science teacher preparation with STEM-oriented curriculum reform (Sulaeman et al., 2022). These studies demonstrate that implementation challenges exist, but their samples and contexts do not justify conclusions about the prevalence of lecture-based teaching, large classes, inadequate laboratories, or digital-resource shortages among Indonesian teachers nationally. The findings are therefore treated as context-specific

Table 2. Comparative overview of science curriculum structure and content for ages 11-12 in six developing Asian education systems

Country	Curriculum framework	Approximate stage for ages 11-12	Organization of science	Main content emphasis	Distinctive curriculum feature
India	NCF 2005 and emerging reforms under NEP 2020	Upper primary/ transition to lower secondary	Integrated general science	Food, materials, living world, motion, natural phenomena, natural resources, and everyday science contexts	Strong constructivist orientation in NCERT textbooks and emphasis on scientific temper
Indonesia	Kurikulum Merdeka	Upper primary/ beginning of junior secondary	IPAS at elementary level and integrated IPA at junior secondary level	Natural and social phenomena, substances, heat, motion, living things, ecology, earth, and solar system	Project-based learning linked to the Pancasila Student Profile
Malaysia	KSSR and KSSM	Upper primary/ transition to lower secondary	Integrated science	Life science, physical science, materials science, earth and space science, technology, and sustainable living	Strong emphasis on science process skills, HOTS, STEM, and dual-language possibilities
Pakistan	SNC	Upper primary/ lower secondary transition	Integrated general science	Life science, physical science, earth and space science, environmental science, and scientific inquiry	Attempt to establish common national learning standards across a fragmented education system
Philippines	K to 12 science curriculum guide	Upper elementary/ beginning of junior high school	Integrated science organized through spiral progression	Earth and space, living things and environment, force, motion and energy, and matter	Spiral curriculum revisits all major domains with increasing complexity
Thailand	Basic education core curriculum 2008	Upper primary/ lower secondary transition	Integrated science, with possible school-level variation at lower secondary	Life processes, environment, substances, force and motion, energy, earth processes, astronomy, and technology	Explicit strand on the nature of science and technology

Note. The table synthesizes curriculum features discussed in the comparative analysis and is intended to support the transition from country-level description to cross-national interpretation.

evidence rather than as representative of all schools, rural areas, or teachers implementing Kurikulum Merdeka.

In Malaysia, the official pedagogical vision for science education, as articulated in the KSSR and KSSM curriculum documents and the Malaysia education blueprint 2013-2025, emphasizes HOTS, inquiry-based learning, STEM integration, and the cultivation of scientific creativity and innovation. The Malaysia education blueprint 2013-2025 describes national initiatives intended to strengthen higher-order thinking, STEM participation, assessment practice, and teachers' professional development (Ministry of Education Malaysia, 2013). These initiatives document the policy support provided for pedagogical reform, but they do not establish how consistently inquiry-oriented science teaching is enacted across Malaysian classrooms. The evidence corpus does not contain nationally representative classroom studies sufficient to conclude that chalk-and-talk instruction is the dominant approach in rural or lower socio-economic schools. It also does not establish that participation in the dual language program leads teachers or students to rely on memorization rather than conceptual engagement. These issues are therefore identified as areas requiring further empirical investigation rather than presented as nationwide findings. The Malaysia Education Blueprint 2013-2025 identifies proficiency in both Bahasa Malaysia and English as an important national educational objective (Ministry of Education Malaysia, 2013). In science education, differences between the language of instruction and the language used in some instructional resources may create difficulties for certain learners. However, the evidence reviewed in this study does not establish the

prevalence or magnitude of this issue; language is therefore treated as a potential implementation condition rather than a demonstrated nationwide barrier.

India presents a particularly complex landscape for science pedagogy, shaped by the country's vast scale, enormous diversity of schooling contexts, and the deep structural divide between relatively well-resourced private and urban schools and the under-resourced government schools that serve the majority of the population. The NCF 2005 articulates a constructivist vision for science education based on activity, inquiry, collaborative learning, formative assessment, and connections with learners' everyday environments (National Council of Educational Research and Training, 2005). Research involving Indian pre-service teachers indicates that the enactment of inquiry-based science education is influenced by teachers' conceptions of inquiry, their pedagogical preparation, and their opportunities to practice inquiry-oriented teaching (Bansal, 2021). Because this evidence concerns a specific pre-service-teacher context, it should not be treated as representative of science teaching throughout India. The national education policy 2020 proposes reforms to teacher education, including multidisciplinary integrated programs and continuing professional development (Ministry of Education, Government of India, 2020). The sources reviewed do not provide nationally representative estimates sufficient to support claims about a general shortage of science teachers, a near-total absence of functional laboratories, or classes routinely exceeding fifty or sixty students. These conditions are therefore not presented as nationwide characteristics of Indian science education.

Pakistan's SNC documents promote inquiry-based learning, hands-on activities, scientific reasoning, and the development of scientific process skills at the upper-primary and lower-secondary levels (National Curriculum Council, 2020a, 2020b). These documents describe the intended pedagogical approach and suggested learning activities rather than observed classroom practice. The evidence included in this review is insufficient to characterize Pakistani science teaching as overwhelmingly lecture-based or to provide nationally representative estimates of teachers' qualifications, laboratory availability, instructional resources, or professional-development provision. It also does not permit the conclusion that Pakistan's implementation gap is among the widest in Asia. Accordingly, the analysis is restricted to documented curriculum intentions, while the extent and variation of classroom enactment are identified as matters requiring Pakistan-specific empirical investigation.

Thailand's basic education core curriculum and revised science standards promote learner-centered education, inquiry, critical thinking, problem-solving, investigation, data interpretation, and the application of scientific knowledge to everyday situations (Institute for the Promotion of Teaching Science and Technology, 2017; Ministry of Education Thailand, 2008). A case study of junior-high-school science classrooms reported difficulties in consistently enacting inquiry-based science education in the settings examined, particularly where teachers had limited support, resources, or experience with inquiry-oriented instruction (Mashita et al., 2017). Because this evidence is context-specific, it does not establish the prevalence of teacher-centered instruction throughout Thailand or demonstrate that large classes, insufficient laboratories, teacher qualifications, cultural norms, and entrance examinations operate as nationwide barriers. The study is therefore used to illustrate possible implementation difficulties rather than to characterize Thai science pedagogy nationally.

The Philippine K to 12 science curriculum guide promotes scientific literacy through inquiry-oriented and constructivist teaching, including hands-on experiments, collaborative investigations, fieldwork, and the use of local materials (Department of Education, 2016). Its spiral-progression structure is intended to provide repeated opportunities for students to develop increasingly complex scientific understanding and inquiry skills. Philippine research indicates that students' progress within this curriculum may depend on alignment, continuity, prior knowledge, instructional quality, and the availability of learning support in the contexts examined (Garcia, 2021). However, the reviewed evidence does not provide nationally representative estimates of specialist-teacher shortages, class sizes, laboratory functionality, or the effects of English-medium instruction. It also does not establish that lecture, textbook reading, and memorization are the dominant practices in most Philippine public schools. These conditions are therefore not presented as nationwide findings.

The comparison identifies clearer convergence in prescribed pedagogy than in documented classroom practice. Official frameworks across the six systems promote inquiry, scientific reasoning, active participation, and the application of knowledge, although their terminology and curricular organization differ. Comparative curriculum research similarly shows variation in how science and engineering practices are represented in Asian curriculum frameworks (Prasoplarb et al., 2024). Conceptual research indicates that enacting inquiry requires alignment among curriculum goals, classroom activities, teacher preparation, assessment, and opportunities for practical investigation (Kotsis, 2024a, 2024c; Kotsis et al., 2025a). However, these general principles do not establish the prevalence of particular implementation constraints in the six countries examined. The country-specific evidence identifies challenges related to teacher preparation, resources, language, and assessment in particular contexts, but it does not demonstrate that teacher shortages, episodic professional development, inadequate laboratories, or recall-oriented examinations characterize all six systems. These factors are therefore interpreted as recurrent but differently evidenced implementation considerations rather than as uniform cross-national findings.

Table 3 summarizes the implementation conditions identified in the reviewed sources for the six education systems. Because the available evidence is uneven, context-specific, and based on different types of sources, **Table 3** does not imply that every reported condition occurs in every system or establish its national prevalence. It distinguishes intended curriculum features from the evidence concerning reported implementation conditions and identifies the evidential limitations affecting cross-national interpretation.

DISCUSSION

The comparison identifies convergence in several intended curriculum goals, particularly scientific literacy, inquiry, competency development, and integrated science. Evidence concerning classroom enactment is less consistent and varies considerably in scope and strength among the six countries. The discussion therefore focuses on policy-level similarities, documented country-specific implementation conditions, and the limits of cross-national inference.

The official documents reveal partial convergence in curriculum language, particularly around scientific literacy, inquiry, scientific processes, competency development, and connections with everyday life. However, these priorities are organized differently within Indonesia's integrated IPAS model, the Philippines' spiral progression, Thailand's standards-based structure, India's constructivist framework, Malaysia's STEM-oriented curriculum, and Pakistan's SNC. Shared terminology does not establish substantive equivalence among these curricula or

Table 3. Evidence-bounded comparison of science curriculum implementation for students aged 11-12

Country	Intended curriculum	Evidence identified in the review	Interpretation and evidential limitation
India	NCF 2005 and NCF 2023 promote activity-based, inquiry-oriented, collaborative, and competency-based science learning.	A study of pre-service teachers identified variation in conceptions and enactment of inquiry. A case study examined tensions created by English in translating science policy into practice (Bansal, 2021, 2022).	The evidence is context-specific. It does not provide national estimates of specialist-teacher shortages, class size, laboratory availability, or dominant pedagogy.
Indonesia	Kurikulum Merdeka promotes differentiated learning, projects, inquiry, and integrated IPAS at the elementary level.	Studies in selected settings reported difficulties with the scientific approach, STEM integration, facilities, and alignment between teacher preparation and reform (Nasir et al., 2020; Arlinwibowo et al., 2023; Sulaeman et al., 2022).	The studies establish the existence of implementation difficulties in the settings examined, not their national prevalence or concentration in rural schools.
Malaysia	KSSR, KSSM, and the Malaysia education blueprint promote inquiry, higher-order thinking, STEM integration, and scientific literacy.	The reviewed corpus documents national policy priorities and intended support for assessment and professional development (Ministry of Education Malaysia, 2013).	The evidence does not establish that chalk-and-talk teaching is nationally dominant or that the Dual Language Program produces particular pedagogical outcomes.
Pakistan	The SNC documents promote inquiry, hands-on activity, scientific reasoning, and science process skills.	The reviewed Pakistan-specific evidence is concentrated on official curriculum and textbook content, including the meanings conveyed through textbooks (Shah, 2023; Yasmin et al., 2026).	The corpus does not support national estimates of teacher qualifications, laboratory provision, class size, professional development, or prevailing classroom practice.
Philippines	The K to 12 and MATATAG science guides promote scientific literacy, inquiry, active learning, and progressive conceptual development.	Studies identify curriculum alignment, continuity, prior knowledge, instructional quality, and learning support as relevant in the contexts examined (Balagtas et al., 2019; Garcia, 2021).	The evidence does not quantify nationwide teacher shortages, class size, laboratory functionality, language effects, or the prevalence of lecture-based teaching.
Thailand	The basic education core curriculum and revised science standards promote learner-centered inquiry, scientific processes, reasoning, and the nature of science.	A junior-high-school case study reported difficulties in consistently enacting inquiry. A separate study developed resources for under-resourced settings (Mashita et al., 2017; Hemtasin et al., 2026).	These studies illustrate context-specific conditions and interventions; they do not establish nationwide pedagogical, staffing, resource, or assessment patterns.

Note. The table presents the author's synthesis of curriculum structure, content organization, and intended pedagogical orientation. It does not represent observed classroom implementation (Source. Badan Standar, Kurikulum, dan Asesmen Pendidikan (n.d.-a, n.d.-b); Department of Education (2016, 2023); Institute for the Promotion of Teaching Science and Technology (2017); Ministry of Education Malaysia, Curriculum Development Division (n.d.-a, n.d.-b); Ministry of Education Thailand (2008); National Council of Educational Research and Training (2005, 2023); and National Curriculum Council (2020a, 2020b)).

demonstrate that they correspond closely to those of higher-performing Asian systems. The reviewed evidence also does not permit the observed similarities to be attributed directly to PISA, TIMSS, or international organizations. The comparison therefore supports a more limited conclusion: the six systems share aspects of an international reform vocabulary while retaining distinct national curriculum structures, priorities, and implementation contexts.

Teacher preparation and professional support emerge as relevant implementation considerations, although the evidence differs substantially among countries. Studies involving Indian pre-service teachers and selected Indonesian and Thai settings identify challenges in understanding or enacting inquiry-oriented and integrated science teaching (Bansal, 2021; Mashita et al., 2017; Nasir et al., 2020; Sulaeman et al., 2022). These studies do not provide comparable national estimates of specialist-teacher availability or professional-development quality. Evidence is particularly limited for determining the prevalence of such

conditions in Malaysia, Pakistan, and the Philippines. The analysis therefore does not claim that teacher shortages or episodic professional development characterize all six systems, nor does it rank their institutional capacity against that of higher-performing Asian countries.

Access to practical and instructional resources is relevant to the enactment of inquiry because experimentation connects scientific concepts with observation, evidence, and reasoning (Kotsis, 2024c). Within the reviewed corpus, studies from selected Indonesian and Thai settings identify facilities or instructional materials as implementation considerations (Arlinwibowo et al., 2023; Hemtasin et al., 2026). However, these studies do not establish the national prevalence of non-functional laboratories, equipment shortages, large classes, or inadequate digital access. Nor does the evidence permit comparative claims that particular countries or school sectors experience more severe shortages than others. Resource limitations are therefore discussed only as context-specific conditions reported in particular studies,

while digital initiatives are treated as policy responses rather than demonstrated substitutes for practical science provision.

Assessment structures differ among the six systems, including national, regional, school-transition, and classroom-based arrangements. Indonesia's replacement of the Ujian Nasional with the competency-oriented Asesmen Nasional illustrates an explicit policy effort to broaden the purposes of assessment. However, the reviewed corpus does not provide comparable evidence showing that examinations in all six countries primarily reward factual recall or that they uniformly cause teachers to reduce inquiry-based instruction. Assessment alignment is therefore presented as a curriculum-design principle rather than as a directly established cross-national finding: when curricula prioritize investigation, evidence interpretation, explanation, and application, assessment should provide opportunities to demonstrate these competencies. The extent to which existing assessments achieve this alignment requires country-specific analysis. In the present comparison, this relationship is interpreted as a potential implementation constraint rather than as a classroom pattern directly demonstrated across all six education systems.

Language-of-instruction arrangements differ substantially among the six systems and may influence students' opportunities to participate in scientific discussion, explanation, and argumentation. The clearest country-specific evidence in the reviewed corpus comes from India, where a case study identified tensions associated with translating English-dominant science policy into linguistically accessible classroom practice (Bansal, 2022). For Malaysia, Pakistan, the Philippines, Indonesia, and Thailand, the available sources describe multilingual policy contexts more adequately than they establish classroom effects for students aged 11-12. The analysis therefore does not rank these systems by the severity of language barriers or assume that instruction in a national language necessarily produces fewer difficulties. A cautious policy implication is that curriculum implementation should consider appropriate linguistic support, but the balance among familiar-language instruction, bilingual resources, and English scientific terminology must be determined within each national and local context.

Geographical and socio-economic differences may influence how a common national curriculum is enacted, particularly through variation in teacher preparation, instructional resources, digital access, and local institutional capacity. However, the evidence reviewed is uneven across countries and does not establish that urban students consistently experience inquiry-oriented science while rural students predominantly experience textbook-based instruction in all six systems. The comparison therefore treats geographical inequality as a context-sensitive implementation consideration rather than a uniform cross-national finding. Where national or local

evidence demonstrates unequal implementation conditions, targeted support for disadvantaged schools, teachers, and learners may be appropriate; the form and priority of such measures should be determined using country-specific data.

The comparison suggests that curriculum development should be considered together with the conditions required for implementation. Because the six systems are at different stages of reform and the evidence concerning enactment is uneven, the analysis cannot conclude that further curriculum revision is unnecessary or that implementation support should be the same national priority in every case. Country-specific evaluation is needed to determine whether attention should focus on curriculum content, teacher preparation, instructional resources, language support, assessment alignment, equity measures, or combinations of these areas.

The category "developing Asian education systems" does not imply curricular homogeneity. The six frameworks combine shared reform themes with distinct national configurations: Indonesia integrates science and social studies through IPAS; India emphasizes constructivist and activity-based learning; Malaysia foregrounds STEM and higher-order thinking; Pakistan seeks common standards through the SNC; the Philippines uses spiral progression; and Thailand gives explicit attention to the nature of science and technology. These are features of intended curriculum rather than evidence of successful implementation. The comparison therefore treats the six systems as contextually distinct cases and avoids interpreting their reforms solely through deficit comparisons with higher-performing countries or unsupported assumptions about policy borrowing.

This study was not designed to establish why the six countries differ from higher-performing Asian systems, and the available evidence does not support the conclusion that systemic coherence is the principal explanatory factor. Research on other Asian systems may nevertheless generate useful questions concerning teacher learning, curriculum-assessment alignment, and support for classroom enactment. Such comparisons should be treated as heuristic rather than as evidence that particular policies can be transferred directly between national contexts. The principal implication of the present analysis is therefore modest: decisions about further curriculum revision and implementation support should be based on country-specific evidence concerning teachers, assessment, resources, language, governance, and equity.

Limitations and Future Research

This study has several limitations. First, because the documentary corpus was assembled purposively rather than through an exhaustive systematic-review procedure, source-selection bias cannot be excluded. Accessible, English-language, recent, and officially published documents may have been more readily identified than locally circulated or non-English sources. Evidence

coverage was also unequal: some countries were represented by several official and empirical sources, whereas others relied more heavily on policy documents or broader secondary literature. Accordingly, the frequency with which an implementation issue appears should not be interpreted as an estimate of national prevalence, and the absence of relevant evidence should not be interpreted as evidence that a constraint does not exist. Official documents establish intended curriculum, while empirical and secondary sources provide context-specific accounts of reported implementation conditions; they do not directly establish enacted curriculum across the six systems.

Second, the currency, version, and language of the documents introduce additional uncertainty. The six systems revise their curricula according to different schedules, and some sources describe earlier frameworks that remain historically relevant but may not reflect current implementation conditions. Online policy documents may also be revised, replaced, or removed without an accessible version of history. Where official English-language versions were unavailable, terminology was interpreted from national-language documents or English-language secondary accounts, potentially reducing the precision of concepts without exact linguistic equivalents. Future research should therefore employ a version-controlled, multilingual corpus and report translation procedures explicitly.

Third, students aged approximately 11-12 do not occupy identical grades or curriculum stages in all six systems. In some countries, this age range falls within upper-primary education, whereas in others it overlaps with the transition to lower-secondary schooling. The comparison consequently concerns a broadly similar developmental period rather than strictly equivalent grades, curriculum sequences, or instructional exposure. Moreover, PISA assesses 15-year-olds and TIMSS is organized by grade; their findings cannot directly establish curriculum quality for the 11-12 age group examined here. Future research should undertake more precise age- and grade-specific comparisons of curriculum content, textbooks, instructional time, assessment tasks, and learning outcomes.

Fourth, evidence extraction, coding, and comparative interpretation were conducted by one researcher. The predefined coding matrix, repeated checking, and maintenance of an audit trail improved procedural consistency, but no independent coder was available to verify decisions or calculate inter-coder agreement. Researcher judgement may therefore have influenced the classification of curriculum features and implementation conditions, as well as the distinction between evidence and interpretation. Future studies should employ at least two independent coders and report their procedures for assessing agreement and resolving differences.

Fifth, internationally comparable assessment evidence was not equally available for the six systems. Malaysia, Thailand, Indonesia, and the Philippines have participated

in PISA and/or TIMSS, whereas India's participation has been limited and Pakistan has not participated in PISA. Furthermore, these assessments do not necessarily concern the specific age group examined in this study. International assessment results were therefore used only as contextual indicators and not as direct measures of curriculum effectiveness. Future research should combine appropriately matched international and national assessments with classroom observations, textbook analyses, and evidence from teachers and students.

Sixth, the national level of analysis cannot capture the full internal diversity of each education system. This limitation is particularly important in large or decentralized countries such as India, Indonesia, Pakistan, and the Philippines, where curriculum interpretation and implementation may vary across states, provinces, regions, languages, school sectors, and urban-rural settings. The national patterns identified in this study should therefore not be interpreted as representative of every school or classroom within a country. Future research should undertake subnational comparisons and examine directly how curriculum enactment is mediated by local governance, teacher preparation, instructional resources, language policy, school context, and community conditions.

CONCLUSIONS

This paper compared the intended science curricula for students aged 11-12 in India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand, together with the implementation conditions reported in the available literature. Three main conclusions emerge. First, the official frameworks display partial convergence around scientific literacy, inquiry, scientific processes, competency development, and connections between science and everyday life. These shared priorities are nevertheless organized through different national structures, including integrated subjects, spiral progression, standards-based frameworks, and distinct interdisciplinary arrangements. The findings therefore indicate a shared reform vocabulary rather than curricular equivalence among the six systems or close correspondence with higher-performing Asian countries.

Second, evidence concerning curriculum enactment is more limited and uneven than evidence concerning curriculum intentions. Country-specific studies identify possible implementation constraints related to teacher preparation, instructional resources, assessment, language, and geographical inequality, but these factors are not documented with equal strength in every country. The available evidence therefore supports the existence of context-specific differences between intended and enacted curriculum but does not establish a uniform implementation gap or a common set of constraints across all six systems.

Third, national differences remain essential to interpreting the comparison. Indonesia's integrated IPAS

model, India's constructivist framework, Malaysia's STEM orientation, Pakistan's effort to establish common standards, the Philippines' spiral progression, and Thailand's attention to the nature of science represent distinct curriculum responses to national priorities. These features describe intended curriculum and should not be interpreted as evidence of successful implementation. Future decisions should therefore be informed by country-specific evaluation that considers both the continuing suitability of curriculum design and the support required for classroom enactment.

The findings identify several areas that may warrant policy attention, depending on national and local evidence: teacher preparation and professional learning, alignment between curriculum and assessment, access to practical and digital resources, linguistic support, and equitable implementation across different school contexts. The relative importance and appropriate form of these measures cannot be determined uniformly for all six systems. Policy responses should therefore be based on country-specific needs assessments and accompanied by evaluation of their effects on classroom practice and student learning.

The analysis indicates that curriculum design and implementation support should be evaluated together rather than treated as competing reform priorities. The evidence does not justify assuming that existing curricula are already sufficiently designed or that the same investments are required in every country. Future policy decisions should draw on national and local evidence concerning curriculum content, teacher preparation, assessment, resources, language, and equity. Comparative research should also examine classroom enactment directly across different regions and school sectors using more consistent methods and evidence sources.

This study provides an evidence-bounded comparison of intended science curricula and reported implementation conditions for students aged 11-12 across six Asian education systems. The findings identify partial similarities in curriculum priorities alongside substantial differences in national structures and unequal evidence concerning classroom enactment. The analysis should therefore be understood as a structured basis for further comparison rather than a definitive assessment of implementation or curriculum effectiveness. Future research combining curriculum analysis with classroom observation, teacher and student evidence, and comparable national data would provide a stronger basis for evaluating how curriculum reform influences science learning.

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