



Why Do East Asian Education Systems Excel in International Mathematics Assessments? A Systematic Review of Evidence from Singapore, Hong Kong, Taiwan, and Macao

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ABSTRACT

Education systems in East Asia consistently score high in international large-scale assessments such as the Program for International Student Assessment and the Trends in International Mathematics and Science Study. Understanding the factors behind this success is important for policymakers and educators aiming to improve mathematics education outcomes worldwide. This study provides a systematic review of research examining the determinants of high performance in the education systems of Singapore, Hong Kong, Taiwan, and Macao. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, relevant studies published between 2000 and 2025 were identified from major academic databases. After screening and quality appraisal with the Mixed Methods Appraisal Tool (MMAT), 30 studies were included in the final analysis. Data from these studies were extracted and synthesized to identify common themes that explain the strong performance of these systems in international mathematics assessments. The findings highlight four major factors linked to high student achievement: rigorous teacher preparation and ongoing professional development, coherent, mastery-oriented mathematics curricula, cultural values that support effort and academic achievement, and coordinated governance structures that align curriculum, instruction, and assessment. These elements work together to create educational environments that foster deep conceptual understanding and strong problem-solving skills among students. The review suggests that improving mathematics education requires a systemic approach rather than isolated reforms. Although educational contexts vary across countries, the principles identified here offer useful insights for policymakers and educators seeking to enhance mathematics teaching and learning.

Keywords: Mathematics Education, International Assessments, East Asian Education Systems, Curriculum Coherence, Teacher Preparation, Systematic Review

INTRODUCTION

International large-scale assessments have become important tools for evaluating the effectiveness of education systems and informing educational policy worldwide. Two of the most influential international assessments are the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). These assessments provide comparative data on students' knowledge and skills across countries and enable policymakers and researchers to monitor trends in educational performance and identify areas for improvement (OECD, 2019; Mullis et al., 2020). In the context of the global post-pandemic learning crisis, where many education systems are

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experiencing widening achievement gaps in mathematics, understanding why certain systems consistently perform at high levels has become an urgent priority rather than merely an academic concern.

Over the past two decades, several East Asian education systems have consistently ranked among the highest performers in international mathematics assessments. Singapore, Hong Kong, Taiwan, and Macao frequently rank among the top performers in mathematics across multiple cycles of both PISA and TIMSS (Table 1). These results have attracted considerable attention from researchers and policymakers seeking to understand the characteristics of high-performing education systems and the factors that contribute to sustained student achievement (Schleicher, 2018; Tucker, 2019).

Table 1 Mathematics Performance of Selected East Asian Education Systems in Recent International Assessments

Education System	PISA 2018 Mathematics Score	Global Rank	TIMSS 2019 Grade 8 Score	Global Rank
Singapore	569	1	616	1
Macao	558	2	598	3
Hong Kong	551	4	578	5
Taiwan	531	5	612	2
International average	489		500	

(Source: OECD, 2019; Mullis et al., 2020)

These results illustrate the strong and consistent performance of several East Asian education systems relative to the international average. The sustained success of these systems has generated significant interest among researchers attempting to identify the educational policies, institutional arrangements, and instructional practices that may contribute to high levels of student achievement.

Various explanations have been proposed in the literature to account for the success of high-performing East Asian education systems. Some studies emphasize cultural values that prioritize education, persistence, and respect for teachers (Li, 2012; Tan, 2017). Other research highlights the importance of structural features such as curriculum design, teacher preparation, and governance arrangements that support effective teaching and learning (Schleicher, 2018; Tucker, 2019). In addition, instructional practices and classroom environments have been identified as important factors influencing students' conceptual understanding and problem-solving abilities (Mullis et al., 2020; OECD, 2019).

Despite the growing body of research on high-performing education systems, much of the existing literature examines individual aspects of educational success in isolation, focusing on cultural influences, curriculum design, teacher quality, or governance structures separately. As a result, literature remains fragmented, limiting a comprehensive understanding of how these factors interact. Furthermore, there is currently no systematic synthesis that simultaneously compares the education systems of Singapore, Hong Kong, Taiwan, and Macao using a rigorous protocol such as the PRISMA framework. Existing reviews tend to focus on a smaller subset of systems or adopt narrative approaches without transparent methodological procedures. This creates a clear gap in the literature for an integrated and methodologically rigorous comparative synthesis.

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A systematic synthesis of the existing literature is therefore needed to identify common patterns across studies and to develop a more integrated understanding of the determinants of high performance in East Asian education systems. By examining research on Singapore, Hong Kong, Taiwan, and Macao, this study seeks to consolidate existing evidence and highlight key themes emerging from the literature on high-performing education systems. This study offers novelty by systematically integrating four key dimensions (teacher quality, curriculum coherence, cultural values, and governance structures) within a single analytical framework. Rather than examining these factors in isolation, the study demonstrates how they interact to form a coherent educational ecosystem that underpins sustained high performance across the four regions.

Accordingly, this systematic review addresses the following research questions:

1. What factors have been identified in the literature as contributing to the high performance of East Asian education systems in international assessments?
2. What educational policies and instructional practices are associated with high mathematics achievement in Singapore, Hong Kong, Taiwan, and Macao?
3. What common themes emerge across studies examining high-performing education systems?

RESEARCH METHOD

Research Design

This study employed a systematic literature review to synthesize existing research on the factors contributing to the high performance of East Asian education systems in international assessments. Systematic reviews are widely used in educational research to provide a comprehensive and transparent synthesis of existing literature by following clearly defined procedures for identifying, selecting, and analyzing relevant studies. Compared with traditional narrative reviews, systematic reviews minimize bias by using explicit search strategies and inclusion criteria (Snyder, 2019).

The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which provide a structured framework for conducting systematic reviews and reporting study selection. The PRISMA approach involves four major stages: identification, screening, eligibility assessment, and inclusion of relevant studies.

Search Strategy

A comprehensive literature search was conducted to identify relevant studies examining the determinants of high performance in East Asian education systems, particularly in relation to mathematics achievement in international assessments. The search focused on studies examining the educational systems of Singapore, Hong Kong, Macao, and Taiwan, which have consistently performed well on international large-scale assessments such as PISA and TIMSS. Electronic database searches were conducted in Scopus, Web of Science, ERIC (Education Resources Information Center), and Google Scholar. These databases were selected due to their extensive coverage of peer-reviewed research in education, comparative education, and mathematics education.

To ensure transparency and reproducibility, the search strategy employed a structured combination of keywords using Boolean operators as follows: (“PISA” OR “TIMSS”) AND (“high-

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performing education systems” OR “East Asian education systems”) AND (“mathematics achievement” OR “student performance”) AND (“Singapore” OR “Hong Kong” OR “Taiwan” OR “Macao”). These search strings were adapted across databases to align with indexing requirements. The search was limited to studies published between 2000 and 2025, a period during which international large-scale assessments have gained prominence in global education research. The study selection process followed a structured protocol involving title screening, abstract screening, and full-text review.

Inclusion and Exclusion Criteria

To ensure the relevance and quality of the studies included in the review, clear inclusion and exclusion criteria were established prior to screening. Studies were eligible if they were published in peer-reviewed academic journals, focused on international large-scale assessments, specifically the PISA or the TIMSS, and examined the education systems of Singapore, Hong Kong, Macao, or Taiwan.

Additionally, these studies needed to investigate factors related to student achievement or education system performance and must have been published in English between 2000 and 2025. Conversely, studies were excluded if they were conference papers, editorials, or opinion pieces; did not focus on education systems or student achievement; lacked international assessment data; or centered on countries outside the scope of the study.

Study Selection Process

The study selection process followed the PRISMA framework. The literature search yielded 540 records across four databases: Scopus (148), Web of Science (92), ERIC (86), and Google Scholar (214). After removing 120 duplicate records, 420 articles remained for title and abstract screening. During this stage, 310 articles were excluded because they were not related to international assessments, did not focus on East Asian education systems, or did not examine mathematics achievement. The remaining 110 articles were subjected to full-text review. Of these, 80 articles were excluded for reasons including a lack of analysis of PISA or TIMSS data, a focus on countries outside the study's scope, a conceptual or opinion-based focus, or insufficient methodological detail. Ultimately, 30 studies met the inclusion criteria and were included in the final qualitative assessment synthesis.

The study selection process is summarized in Figure 1, which presents the PRISMA flow diagram detailing identification, screening, eligibility, and inclusion stages.

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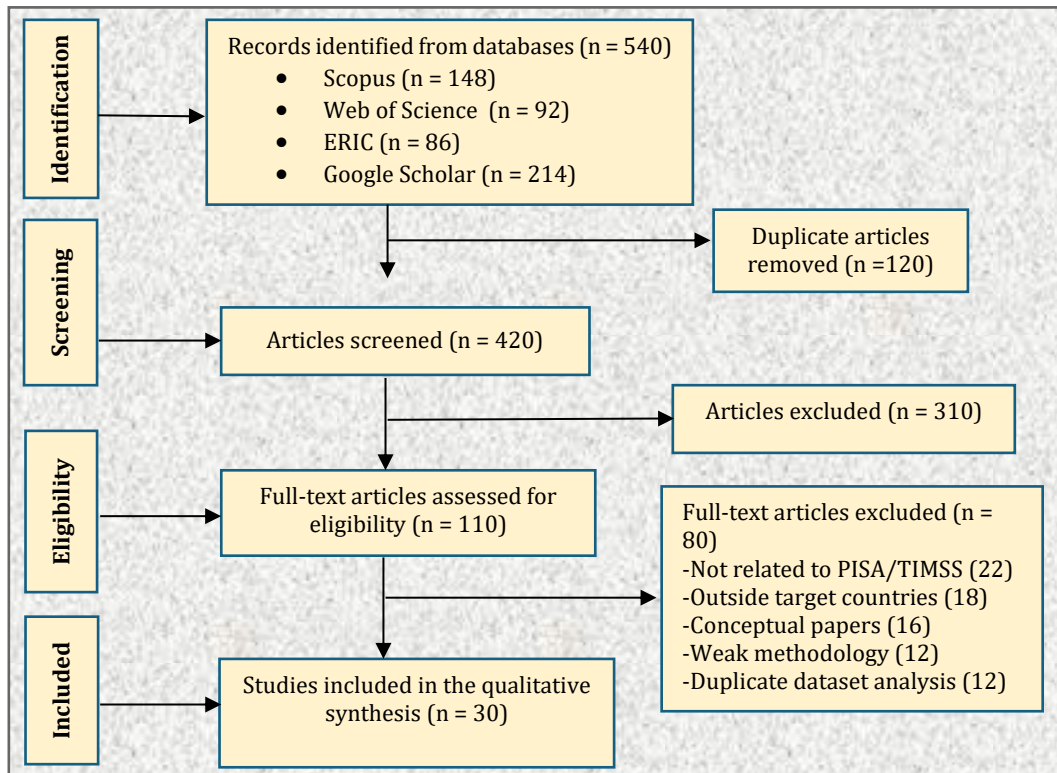


Figure 1 PRISMA flow diagram illustrating the study selection process for the systematic review

Quality Appraisal

To ensure the methodological rigor of the studies included in the review, a quality appraisal was performed using the Mixed Methods Appraisal Tool (MMAT). The MMAT is commonly used in systematic reviews that encompass qualitative, quantitative, and mixed-methods research designs because it provides a structured framework for assessing methodological quality across study types (Hong et al., 2018).

The 30 studies included in this review were evaluated using the MMAT criteria. The assessment focused on key aspects of methodological quality to ensure that the findings summarized in this review were based on studies with sufficient research rigor. In line with the MMAT guidelines, five methodological criteria were assessed for each study. These criteria included: (1) the clarity of the research questions or objectives, (2) the suitability of the research design for addressing the research questions, (3) the adequacy and relevance of the data collection methods, (4) the rigor and appropriateness of the data analysis procedures, and (5) the consistency between the data, the analysis, and the conclusions drawn by the authors (Hong et al., 2018).

Each criterion was assessed using the MMAT rating categories “Yes,” “No,” or “Cannot determine.” A numerical quality score was assigned to each study based on the number of criteria met. Although the developers of the MMAT caution against reducing methodological quality to a single numerical score, this study adopted a scoring approach to facilitate comparisons across studies and enhance transparency in reporting overall quality levels. This

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approach has been applied in previous systematic reviews to provide a concise summary of methodological rigor while maintaining consistency in quality assessment. Studies that satisfied all five criteria received a score of 5/5, indicating high methodological quality. Those meeting four criteria received a 4/5 score, while those meeting three criteria received a 3/5 score. Studies with fewer than three criteria satisfied were considered to have insufficient methodological rigor and were excluded during the review's eligibility stage.

For interpretation purposes, studies scoring 4/5 or 5/5 were classified as high quality, while studies scoring 3/5 were considered to have moderate methodological quality. Overall, most studies included in the review demonstrated moderate to high methodological quality, suggesting that the evidence base for analyzing high-performing education systems in international assessments is methodologically strong.

The results of the quality appraisal are shown in Table 2, which summarizes the characteristics of the 30 studies included in the review, such as the country or education system analyzed, the dataset used (e.g., PISA or TIMSS), the methodological approach, and the MMAT quality score assigned to each study.

Table 2 Characteristics and Quality Appraisal of Studies Included in The Systematic Review

No	Author(s)	Year	Country /System	Dataset	Method	MMAT Score	Quality
1	OECD	2019	Singapore, Hong Kong, Taiwan, Macao	PISA	Quantitative	5/5	High
2	Mullis et al.	2020	Singapore, Hong Kong, Taiwan	TIMSS	Quantitative	5/5	High
3	Schleicher	2018	Singapore	PISA	Quantitative	4/5	High
4	Tan	2017	Singapore	Policy analysis	Qualitative	4/5	High
5	Tucker	2019	Singapore, Hong Kong	Comparative	Mixed	4/5	High
6	Li	2012	China, Singapore	Comparative	Qualitative	4/5	High
7	Leung	2014	Hong Kong	TIMSS	Quantitative	4/5	High
8	Cai & Wang	2010	East Asia	TIMSS	Quantitative	4/5	High
9	Ng & Rao	2010	Singapore	Curriculum	Qualitative	4/5	High
10	Wong	2018	Hong Kong	PISA	Mixed	4/5	High
11	Jerrim	2015	Singapore, Hong Kong	PISA	Quantitative	4/5	High
12	Byun & Park	2012	East Asia	PISA	Quantitative	4/5	High
13	Areepattamannil & Caleon	2013	Singapore	PISA	Quantitative	4/5	High

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No	Author(s)	Year	Country /System	Dataset	Method	MMAT Score	Quality
14	Sandoval-Hernandez & Bialowolski	2016	East Asia	TIMSS	Quantitative	4/5	High
15	Qiu & Leung	2022	Hong Kong	TIMSS	Quantitative	4/5	High
16	Huang	2017	Taiwan	Teacher education	Qualitative	4/5	High
17	Cheng	2015	Hong Kong	PISA	Quantitative	4/5	High
18	Lee & Lee	2016	Taiwan	TIMSS	Quantitative	4/5	High
19	Wang & Lin	2015	East Asia	Comparative	Qualitative	4/5	High
20	Ng	2018	Singapore	Curriculum	Qualitative	4/5	High
21	Tan & Dimmock	2014	Singapore	Comparative	Mixed	4/5	High
22	Zhu & Leung	2012	Hong Kong	TIMSS	Quantitative	4/5	High
23	Zhu & Leung	2011	Hong Kong	TIMSS	Quantitative	4/5	High
24	Lin & Li	2009	Taiwan	TIMSS	Quantitative	4/5	High
25	Marsh & Hau	2004	Hong Kong	Comparative	Quantitative	4/5	High
26	Chan	2016	Hong Kong	Policy study	Qualitative	3/5	Moderate
27	Lim	2015	Singapore	Curriculum analysis	Qualitative	3/5	Moderate
28	Zhao	2012	East Asia	Comparative	Qualitative	3/5	Moderate
29	Seah & Wang	2024	East Asia	Comparative	Qualitative	4/5	High
30	Tan & Gopinathan	2000	Singapore	Policy analysis	Qualitative	4/5	High

Data Extraction

Following the quality appraisal process, relevant information from the studies that met the inclusion and methodological quality criteria was systematically extracted for further analysis. Instead of creating a separate table, the extracted information was incorporated into the same table used for the quality appraisal results (Table 2). In addition to the study characteristics and MMAT quality scores, the table was expanded to include a column summarizing each study's key findings. The key findings on the determinants of high performance in international assessments were summarized, offering insights into the factors associated with success in these evaluations.

By integrating the extracted information with the quality appraisal table, a clear overview of the methodological features and main findings of all included studies was provided. This organized approach made it easier to compare evidence across studies and helped identify recurring themes explaining the sustained high performance of East Asian education systems in international assessments.

Data Analysis

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The extracted data were analyzed using thematic analysis following a structured multi-step process. First, relevant findings from each study were coded inductively to identify recurring concepts related to educational performance. Second, similar codes were grouped into broader categories that represent key dimensions, such as teacher quality, curriculum design, cultural influences, instructional practices, and governance. Third, these categories were refined into overarching themes through iterative comparison across studies.

To enhance rigor, the coding process involved repeated review of the extracted data to ensure consistency and alignment between codes and themes. The final themes were derived based on their frequency, relevance, and explanatory power in accounting for high performance across the four education systems.

RESULTS AND DISCUSSION

The analysis of the 30 studies included in this systematic review uncovered several recurring themes that explain the sustained high performance of East Asian education systems in international assessments such as the PISA and the TIMSS. The findings suggest that the success of systems in Singapore, Hong Kong, Macao, and Taiwan stems from a combination of interconnected cultural, institutional, and instructional factors rather than a single cause. Five main themes emerged from the literature review: teacher quality, curriculum coherence, cultural values toward education, instructional practices, and educational governance.

While the findings highlight common strengths across the four systems, it is important to recognize that these factors do not operate uniformly across contexts. Differences in policy implementation, socio-economic conditions, and educational priorities suggest that the effectiveness of these factors may vary between systems. Furthermore, the interaction among these elements appears to be more significant than any single factor in isolation.

These findings are interpreted comparatively across the four systems to highlight both common patterns and context-specific variations, with particular attention to how institutional and cultural factors interact to shape educational outcomes.

Teacher Preparation and Continuous Professional Development

A common theme across the studies reviewed is that high-performing East Asian education systems see teacher quality as the result of a comprehensive professional system rather than just a single policy. In systems like Singapore, Hong Kong, and Taiwan, teacher education features clear entry routes, extensive clinical preparation, and ongoing professional development throughout teachers' careers (Schleicher, 2018; Tan, 2017; Tucker, 2019). These parts work together to maintain high standards in teaching and learning.

In these systems, multiple pathways into the teaching profession exist to fit candidates with different academic backgrounds. One common route is the postgraduate path, designed for those who already hold a university degree in a specific subject. For example, in Singapore, many future teachers enter through the Postgraduate Diploma in Education (PGDE) offered by the National Institute of Education. This program trains university graduates to teach at the primary, secondary, or junior college levels by providing both pedagogical knowledge and practical teaching skills (Darling-Hammond et al., 2017; Schleicher, 2018).

The PGDE usually lasts about 16 months and combines academic coursework with school-based practicum experiences (Darling-Hammond et al., 2017). The curriculum typically

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includes education studies, curriculum studies, practicum experiences, language development, and academic discourse components. These elements are designed to develop teachers' understanding of learners, effective instructional strategies, and professional practice within structured education systems (Darling-Hammond et al., 2017; Schleicher, 2018).

In addition to coursework, teacher trainees complete structured clinical practice in schools, including supervised teaching placements and extended practicum experiences. These opportunities enable trainees to apply theoretical knowledge in authentic classroom settings and progressively assume instructional responsibilities. Such integration of disciplinary preparation with pedagogical training is widely recognized as a key feature of effective teacher education systems, supporting the development of competent and reflective practitioners (Darling-Hammond et al., 2017; Huang, 2017).

Undergraduate teacher education programs provide another route into the profession, preparing candidates directly for teaching careers. These programs usually last four or five years, depending on the system and specialization. In Singapore, undergraduate teacher programs combine subject specialization, educational theory, and pedagogical training over four years. Similarly, Hong Kong offers five-year Bachelor of Education programs that mix academic studies with professional preparation. These generally include coursework in curriculum design, instructional strategies, assessment techniques, and subject-specific pedagogy, ensuring graduates develop solid subject knowledge and effective teaching skills (Cheng, 2015).

Some systems also offer additional pathways tailored to specific educational levels. For example, diploma-level teacher education programs have been used in various contexts to prepare primary school teachers. Although the structure and duration of these programs vary across systems, they typically combine pedagogical coursework with supervised teaching practice, ensuring that candidates develop both theoretical understanding and practical classroom competence (Schleicher, 2018; Tucker, 2019).

A key feature of teacher preparation in these high-performing systems is a strong focus on clinical practice in real classrooms. Candidates complete structured practicum placements under the guidance of experienced mentor teachers. For instance, postgraduate teacher programs in Singapore include teaching assistantships and extended practicums of around 10 weeks, during which trainees gradually assume classroom responsibilities. Similarly, teacher preparation in Hong Kong and Taiwan involves multiple school attachments and extended internships, with some programs requiring up to six months of supervised teaching before certification (Darling-Hammond et al., 2017; Huang, 2017). These experiences help candidates apply their knowledge in real settings and develop vital professional skills before starting work.

Teacher learning continues after initial certification through ongoing professional development (CPD) programs. High-performing systems emphasize continuous learning to maintain high instructional quality and adapt to evolving curriculum standards. For example, teachers in Singapore typically receive about 100 hours of professional development per year, including workshops, postgraduate courses, professional learning communities, mentoring, and leadership training (Schleicher, 2018). In Hong Kong, teachers are generally expected to

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complete at least 150 hours of CPD over three years, showing a strong commitment to ongoing professional growth (Cheng, 2015).

Professional development activities are often organized by national institutions and professional networks. Organizations such as the National Institute of Education in Singapore, teacher development centers in Taiwan, and education authorities in Hong Kong provide structured platforms for teachers to update their knowledge, share best practices, and collaborate on instructional challenges. These systems ensure that professional learning is embedded in the education system itself, not left to individual efforts (Schleicher, 2018; Tucker, 2019).

These structured systems of teacher preparation and professional development help ensure consistent instructional quality across schools, a factor widely recognized as contributing to the strong performance of East Asian education systems in international assessments such as PISA and TIMSS. The evidence reviewed in this study suggests that the strength of these systems lies not simply in the duration of teacher training programs but in the coherence of the entire teacher development pipeline. Rigorous entry pathways, extensive clinical practice, and sustained professional learning collectively foster a professional culture in which teachers continually refine their instructional practices and respond effectively to evolving educational demands (Schleicher, 2018; Tucker, 2019).

While all four systems emphasize rigorous teacher preparation and continuous professional development, their structures and implementations vary in important ways. Singapore's highly centralized model enables strong alignment among teacher education, curriculum, and national policy priorities, whereas Hong Kong and Taiwan exhibit more decentralized features, allowing for greater institutional variation in teacher preparation pathways. These differences suggest that while strong teacher development systems are a common feature, their effectiveness depends on the degree of coherence between policy design and implementation mechanisms within each context.

Furthermore, the findings indicate that teacher quality alone does not account for high performance but operates in conjunction with curriculum design and assessment alignment. This reinforces the view that teacher effectiveness is embedded within a broader systemic framework rather than functioning as an isolated factor.

Curriculum Coherence and Mastery-Based Mathematics Instruction

A second major theme emerging from the reviewed studies concerns the role of curriculum coherence and mastery-focused mathematics instruction in shaping student achievement. Although the mathematics curricula in Singapore, Hong Kong, Taiwan, and Macao broadly cover the same content domains found in many education systems participating in the PISA and TIMSS, including number, algebra, geometry, measurement, and statistics, the key difference lies in how these topics are structured, sequenced, and taught (Cai & Wang, 2010; Leung, 2014; Ng & Rao, 2010). Rather than superficially introducing many topics, these systems emphasize conceptual depth and the logical progression of mathematical ideas, ensuring that students build a strong foundation before moving on to more complex concepts (Tan & Dimmock, 2014).

A key feature of these curricula is how mathematical topics are arranged across grade levels. While there are elements of a spiral approach, where topics reappear at higher levels of

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complexity, the curriculum is better described as cumulative and focused on mastery. Concepts are introduced step by step and revisited only after students have achieved a solid understanding of the necessary background knowledge (Ng & Rao, 2010). For instance, foundational topics like number sense and fractions are emphasized in elementary school before students progress to algebraic reasoning and proportional thinking in early secondary education. This sequential design helps students form connections across different areas of mathematics and supports long-term retention of knowledge (Leung, 2014).

Instructional time also plays a key role in the effectiveness of these curricula. Evidence from the reviewed literature indicates that mathematics receives a significant and consistent share of instructional time in these systems. In Singapore, for example, primary school students usually receive about five to six mathematics lessons per week, each lasting roughly one hour. Similar patterns are observed in Hong Kong, Taiwan, and Macao, where students typically receive four to five mathematics lessons per week (Cai & Wang, 2010). However, research indicates that the effectiveness of these systems depends not just on the amount of instructional time, but also on how lessons are organized. Classroom instruction often focuses on a few topics per lesson, allowing teachers to delve more deeply into mathematical concepts rather than quickly covering many unrelated ones.

Another key factor identified in the literature is the role of mathematics textbooks and instructional materials. Studies comparing textbooks across countries have found that textbooks used in high-performing East Asian systems typically present mathematical concepts through carefully sequenced explanations and progressively challenging problem sets (Cai & Wang, 2010). Instead of offering numerous procedural exercises, these textbooks often guide students with conceptual explanations, worked examples, and structured problem-solving activities. Problems are often arranged in increasing levels of difficulty, helping students gradually develop a deeper conceptual understanding. Such textbook designs encourage students to explore mathematical reasoning and multiple solution strategies rather than relying solely on memorization of procedures.

Instructional strategies used in classrooms further strengthen the coherence of the curriculum. In addition to the widely recognized Concrete–Pictorial–Abstract (CPA) progression used in Singapore, teachers often employ structured problem-solving frameworks, guided practice, and classroom discussions that encourage students to explain and justify their reasoning (Ng & Rao, 2010; Wong, 2018). Teachers frequently present challenging problems that require students to analyze relationships among mathematical concepts and compare different solution methods (Cai & Wang, 2010; Leung, 2014; Wong, 2018). These practices promote mathematical reasoning and flexible thinking, which are essential components of higher-order problem solving.

A crucial element of curriculum coherence in educational systems is the alignment between curriculum standards, classroom instruction, and assessment practices. The studies reviewed indicate that both national exams and classroom assessments often require students to demonstrate mathematical reasoning, interpret information, and solve multi-step problems, rather than merely performing routine calculations (Leung, 2014; Wong, 2018). Exam papers typically include multiple-choice, short-answer, and extended-response questions that prompt students to explain their reasoning and apply mathematical concepts in unfamiliar contexts

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(Leung, 2014; Wong, 2018; OECD, 2019). Comparative studies of mathematics assessment practices reveal that exam tasks in East Asian education systems often emphasize conceptual reasoning and complex problem-solving over simple computational procedures (Cai & Wang, 2010; Leung, 2014). Evidence from international large-scale assessments shows that students in these systems perform particularly well on tasks that require interpretation, reasoning, and the application of mathematical knowledge to real-world situations (Mullis et al., 2020; OECD, 2019). This strong connection among curriculum goals, teaching methods, and assessment design underscores the deep understanding and problem-solving skills that characterize high-performing mathematics education systems.

Overall, the findings indicate that curriculum coherence is crucial in shaping mathematics learning outcomes. Carefully sequenced curricula, mastery-focused instruction, well-designed textbooks, and assessment systems that emphasize reasoning collectively support deeper conceptual understanding. These elements create an integrated instructional framework that helps explain the consistently strong performance of students in East Asian education systems on international assessments such as PISA and TIMSS.

Despite shared characteristics of curriculum coherence and mastery orientation, variations exist in how these principles are enacted across the four systems. For instance, Singapore's curriculum is often cited for its tightly structured progression and strong integration of the Concrete-Pictorial-Abstract approach, while Hong Kong and Taiwan demonstrate greater flexibility in instructional practices within broadly similar curricular frameworks. Macao, in contrast, reflects influences from both centralized policy structures and localized adaptations.

These differences highlight that curriculum coherence is not a uniform construct but is shaped by national policy traditions and implementation practices. Moreover, the effectiveness of mastery-oriented curricula appears to depend not only on content sequencing but also on alignment with teacher practices and assessment systems. This suggests that curriculum design functions as part of a coordinated instructional system rather than as an independent driver of student achievement.

Cultural Values, Academic Expectations, and Student Motivation

In addition to curriculum design and teacher quality, the reviewed studies highlight the influence of cultural values and societal expectations on student achievement in East Asian education systems. However, rather than treating culture as a uniform explanatory factor, the evidence suggests that cultural influences operate in complex and context-dependent ways across Singapore, Hong Kong, Taiwan, and Macao.

A commonly cited feature across these systems is the emphasis on effort, perseverance, and the high value placed on education, often associated with Confucian heritage traditions (Li, 2012; Tan, 2017). Students are frequently encouraged to view academic success as the result of sustained effort rather than innate ability, which can promote resilience when engaging with challenging mathematical tasks. This orientation aligns closely with mastery-based instructional approaches observed in these systems, reinforcing persistence and deep engagement with content.

However, the influence of cultural values is not uniform across contexts. For example, while strong academic expectations are evident in all four systems, their expression varies

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depending on policy environments and socio-economic conditions. In Singapore, high expectations are often supported by structured national policies and centralized curriculum frameworks, whereas in Hong Kong and Taiwan, greater school-level variation and the influence of private tutoring markets shape students' learning experiences differently. These differences suggest that cultural values alone cannot fully explain educational outcomes without considering the institutional contexts in which they operate.

Moreover, cultural explanations of educational success should be approached with caution. While values such as diligence and respect for education can support high achievement, they may also be associated with unintended consequences. Several studies point to high levels of academic pressure and competition, as well as the widespread use of shadow education systems (private tutoring), which may reinforce inequalities among students (OECD, 2019; Wong, 2018). In this regard, cultural expectations may contribute to both high performance and systemic challenges within these education systems.

Importantly, the findings indicate that cultural values function not as independent determinants of success but as part of a broader ecosystem that includes curriculum design, teacher quality, and governance structures. Cultural norms supporting effort and achievement appear to be most effective when reinforced by coherent institutional arrangements, such as aligned assessment systems and structured instructional practices. This interaction suggests that the role of culture is better understood as complementary to, rather than separate from, structural and policy-related factors.

Overall, while cultural values play a significant role in shaping student motivation and attitudes toward learning, their impact is mediated by contextual and institutional factors. A more nuanced interpretation of culture is therefore necessary: one that recognizes both its supportive role in promoting academic engagement and its potential limitations within high-performing education systems.

Education Governance and Policy Coordination

Another theme found in the studies is the importance of education governance and policy coordination in maintaining high levels of student achievement. In many successful East Asian education systems, education policy features strong coordination among government agencies, curriculum authorities, teacher education institutions, and schools. This coordinated governance setup enables reforms in curriculum, teacher training, and assessment to be carried out consistently and systematically (Schleicher, 2018; Tucker, 2019).

A key feature of the East Asian education systems is the presence of centralized or highly coordinated education authorities that manage curriculum development, teacher training, and national assessment frameworks. For instance, education ministries and curriculum agencies usually take an active part in establishing national standards, creating curriculum guidelines, and tracking educational outcomes. This centralized approach helps maintain consistency in curriculum goals, teaching methods, and assessment strategies across schools (Tan, 2017; Leung, 2014).

Policy coherence is also strengthened through long-term educational planning and ongoing monitoring of system performance. Many East Asian education systems regularly review curriculum frameworks and teaching practices based on evidence from national examinations and international assessments such as PISA and TIMSS. These data sources

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enable policymakers to identify areas for improvement and implement targeted reforms to enhance student learning outcomes (OECD, 2019; Mullis et al., 2020).

Another essential element of governance in East Asian education systems is the strong emphasis on professional accountability combined with institutional support. Teachers and schools are expected to maintain high academic standards, but they also receive support through structured professional development programs, curriculum resources, and instructional guidance from national institutions (Schleicher, 2018; OECD, 2019; Tucker, 2019). This balance between accountability and support helps create conditions in which teachers can focus on improving instructional quality while aligning their practices with national educational goals (Schleicher, 2018).

The reviewed literature also shows that strong governance structures help ensure policy stability and continuity. Instead of making frequent and disruptive policy changes, many East Asian education systems implement reforms slowly and evaluate their effects over time (Schleicher, 2018; Tucker, 2019; OECD, 2020). This stability allows schools and teachers to adjust to new policies while keeping consistency in instructional practices and curriculum delivery (Tucker, 2019).

Overall, the evidence shows that effective governance and policy coordination are crucial for supporting high-performing education systems. By ensuring alignment among curriculum frameworks, teacher development initiatives, and assessment systems, these governance structures help maintain consistent educational standards across schools. When combined with coherent curricula, strong teacher preparation, and supportive cultural attitudes toward education, such policy coordination contributes to the ongoing success of East Asian education systems in international assessments.

While strong governance structures are evident across all four systems, their forms and degrees of centralization differ. Singapore and Macao tend to exhibit more centralized governance models, enabling tighter alignment across curriculum, assessment, and teacher development. In contrast, Hong Kong and Taiwan demonstrate relatively more decentralized features, with greater autonomy at the school or institutional level.

These variations suggest that effective governance is not defined solely by centralization but by the degree of coordination achieved across key components of the education system. The findings indicate that policy coherence, rather than governance structure alone, is critical in sustaining high levels of student performance. This reinforces the importance of viewing governance as an integrative mechanism that connects curriculum, instruction, and assessment within each system.

Discussion and Implications

This systematic review examined the factors behind the consistently high performance of education systems in Singapore, Hong Kong, Taiwan, and Macao on international assessments such as PISA and TIMSS. The analysis of the 30 studies included in the review identified four interconnected factors: teacher preparation and professional development, curriculum coherence and mastery-based instruction, cultural expectations about education, and coordinated education governance. These findings provide a foundation for interpreting how high-performing systems sustain strong learning outcomes.

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Addressing the Research Questions

The first research question asked what factors explain the consistently high performance of East Asian education systems in international assessments. The findings indicate that high achievement cannot be attributed to a single variable. Instead, it results from the interaction of multiple systemic features that reinforce one another. Strong teacher preparation systems ensure that educators possess deep subject knowledge and effective pedagogical skills. Coherent mathematics curricula provide structured learning progressions that emphasize conceptual understanding and mastery of key ideas. Cultural attitudes toward effort and academic achievement support students' persistence in the face of challenging tasks. Finally, coordinated governance structures align curriculum standards, instructional practices, and assessment systems. The interaction of these factors creates learning environments that consistently support high levels of student achievement. However, these findings also suggest that replicating such systems in different contexts may be challenging, as the effectiveness of these factors depends on their alignment within specific cultural and institutional environments.

The second research question examined the specific educational policies and instructional practices associated with high mathematics achievement in the reviewed systems. The findings show that these systems typically prioritize rigorous teacher preparation, extended practicum experiences, and continuous professional development. Mathematics curricula emphasize depth of understanding rather than broad coverage of topics, and classroom instruction often focuses on problem-solving, reasoning, and conceptual connections among mathematical ideas. Assessment systems reinforce these goals by requiring students to demonstrate multi-step reasoning and apply mathematical concepts in unfamiliar contexts.

The third research question focused on identifying common themes across studies examining high-performing education systems. Across the literature, the most consistent themes include strong institutional support for teachers, coherent curriculum frameworks, emphasis on mastery learning, alignment between curriculum and assessment, and high societal expectations regarding education. These elements collectively create educational ecosystems in which students are encouraged and supported to engage deeply with mathematical concepts.

Lessons for Other Education Systems

The findings of this review provide several lessons for countries aiming to improve mathematics education and student outcomes. First, teacher quality should be built through a coherent professional pipeline rather than isolated training efforts. High-performing systems carefully coordinate recruitment, teacher education, practicum experiences, and ongoing professional development. Prospective teachers typically undergo rigorous preparation and extensive clinical practice before entering the classroom, and structured professional learning opportunities continue throughout their careers. Creating such a unified teacher development framework may help ensure consistent instructional quality across schools.

Second, curriculum coherence is crucial for fostering deep mathematical understanding. High-performing systems focus on a few key concepts and develop these ideas

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progressively across grade levels. Instead of covering many topics superficially, mathematics curricula prioritize mastery of essential ideas and the connections between mathematical concepts. Countries aiming to improve mathematics outcomes may find it helpful to review their curriculum frameworks to ensure logical sequencing and conceptual depth.

Third, instructional practices should focus on reasoning and problem-solving. The reviewed studies show that teachers in high-performing systems often engage students in tasks that require explanation, comparison of solution methods, and application of mathematical ideas to unfamiliar situations. These practices help students develop flexible problem-solving skills rather than depending only on memorized procedures.

Fourth, assessment systems should be aligned with curriculum objectives and instructional practices. In high-performing systems, exam questions often require students to demonstrate conceptual understanding and multi-step reasoning. By incorporating similar types of assessment, education systems can promote classroom practices that foster deeper learning instead of solely emphasizing procedural accuracy.

Finally, education reforms should be carried out within coherent governance frameworks. The reviewed studies emphasize the importance of policy coordination and long-term planning in maintaining consistent educational standards. Instead of introducing frequent and disruptive policy shifts, high-performing systems tend to implement reforms slowly and assess their impacts over time. This stability enables teachers and schools to adapt to reforms while sustaining continuity in curriculum delivery and instructional practices.

The synthesis of findings across the four systems points to a broader theoretical implication regarding the nature of educational effectiveness in high-performing contexts.

Theoretical Contributions

Taken together, the findings of this review suggest that high performance in East Asian education systems is best understood through a systemic perspective in which multiple interdependent factors operate in coordination. Rather than supporting single-factor explanations, the evidence points to the importance of alignment among teacher quality, curriculum coherence, cultural expectations, and governance structures.

This study contributes theoretically by advancing an integrated framework of educational effectiveness in which teacher quality, curriculum coherence, cultural expectations, and governance structures operate as interdependent components of a unified system rather than as isolated determinants. Such a perspective extends existing literature by demonstrating that sustained high performance emerges from the interaction of cultural, institutional, and instructional dimensions, thereby offering a more holistic explanation of educational success in high-performing systems.

Implications for Policy and Practice

Overall, the findings indicate that improving mathematics education requires a system-wide approach that links curriculum design, teacher training, assessment methods, and governance. Isolated reforms targeting only one part of the education system are unlikely to lead to lasting improvements in student achievement. Instead, policymakers should focus on how various components of the education system work together to support learning outcomes. Although the educational settings of Singapore, Hong Kong, Taiwan, and Macao differ from

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those of many other countries, the core principles identified in this review (coherent curricula, strong teacher preparation, alignment between instruction and assessment, and supportive educational cultures) are generally applicable. By adapting these principles to their local contexts, education systems worldwide can potentially enhance mathematics learning and better prepare students for increasingly complex problem-solving tasks.

Limitations of the Study

This systematic review provides valuable insights into the factors contributing to the strong performance of East Asian education systems in international assessments. However, several limitations should be acknowledged.

First, the review is based on 30 studies that met the predefined inclusion criteria, which may not fully represent the entire body of research on high-performing education systems. Although the PRISMA approach ensured a systematic and transparent selection process, relevant studies published outside the chosen databases or in languages other than English may have been overlooked.

Second, the studies reviewed utilized various research designs and methodologies, including qualitative analyses, comparative policy studies, and quantitative evaluations of international assessment data. While the Mixed Methods Appraisal Tool (MMAT) helped assess the methodological quality across these diverse studies, differences in research design may have influenced how the findings were interpreted and integrated.

Third, most existing literature focuses on well-known high-performing systems such as Singapore and Hong Kong, with fewer detailed studies on Taiwan and Macao. Consequently, the evidence base may be somewhat uneven across the education systems examined in this review.

Fourth, the review primarily relied on secondary analyses of international assessment data and policy studies, which may not fully capture classroom-level practices across all schools within these systems. Education systems are complex, and practices can vary among schools, teachers, and local contexts.

Finally, while the review identifies several factors associated with high performance, it is important to understand that educational outcomes arise from intricate interactions among cultural, institutional, and socioeconomic factors. Thus, the findings should not suggest that policies from high-performing systems can be directly implemented in other contexts without careful adaptation.

Despite these limitations, the systematic synthesis of evidence from multiple studies offers a comprehensive overview of the structural, instructional, and cultural factors that contribute to the strong performance of East Asian education systems in international mathematics assessments.

CONCLUSION

This systematic review examined the factors contributing to the consistently strong performance of education systems in Singapore, Hong Kong, Taiwan, and Macao on international assessments like PISA and TIMSS. Evidence from 30 studies indicates that the success of these systems cannot be attributed to a single policy or instructional practice. Instead, high levels of student achievement appear to result from the interaction of several

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systemic factors, including rigorous teacher training and ongoing professional development, coherent mathematics curricula focused on mastery, positive cultural attitudes towards education, and coordinated governance structures that align curriculum, instruction, and assessment.

The review highlights that these systems have developed integrated educational frameworks where teacher development, curriculum design, assessment practices, and policy implementation are closely interconnected. Teachers receive thorough preparation and support throughout their careers, mathematics curricula emphasize conceptual understanding and mastery of core ideas, and assessment systems promote reasoning and problem-solving skills. Additionally, strong societal expectations regarding education motivate students to approach learning with persistence and discipline. Together, these elements create educational environments that consistently support high achievement in mathematics.

Despite these insights, several areas warrant further research. First, future studies could investigate classroom instructional practices in greater detail, particularly how teachers in high-performing systems facilitate conceptual understanding and mathematical reasoning during lessons. Second, more research is needed on less-studied systems like Taiwan and Macao, as most existing literature tends to focus on Singapore and Hong Kong. Third, future investigations could explore how the educational strategies identified in this review might be adapted and applied in different cultural and institutional contexts, especially in countries seeking to improve mathematics education outcomes.

Furthermore, comparative research examining the relationship between curriculum coherence, assessment design, and student problem-solving skills could provide additional insights into how educational systems translate policy frameworks into effective classroom practices. Longitudinal studies tracking the impact of specific reforms, such as changes in teacher preparation or curriculum design, would also enhance understanding of how education systems maintain high performance over time.

Overall, the findings of this review suggest that enhancing mathematics education requires a comprehensive, cohesive approach rather than isolated policy changes. By analyzing the experiences of high-performing education systems, policymakers and educators can gain valuable insights into how curriculum, teaching, assessment, and governance structures can work together to foster meaningful and sustained improvements in student learning.

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