Comparative Analysis of Primary and Secondary Mathematics Education in China and The Uk: Insights and Implications

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Abstract. This paper investigates primary and secondary math education in China and the UK through a critical lens, identifying contrasts and parallels using PISA/TIMSS data. Despite China's top-ranked standardized test performance, it struggles with cultivating creativity and critical thinking. The UK's system, prioritizing practical math applications and student experience, enhances appreciation but lacks consistent high academic achievement internationally. Analyzing curricula, teaching methods, and classroom dynamics, China's content-intensive approach yields high scores but pressures students, while the UK offers a more nurturing, holistic learning environment. Examining the China-England Math Teacher Exchange program, it showcases the value of cross-cultural collaboration, revealing pedagogical disparities and shared learning possibilities.

Keywords: Chinese and British mathematics education, international comparison, primary school math education, PISA, MTE program.

1. Introduction

Upon examining the official website of the Programme for International Student Assessment (PISA), it is evident that mainland China secured the top position globally in mathematics in the PISA 2018 assessment. It's shown in figure 1 that while mainland China did not take part in the PISA 2022 evaluation, it is noteworthy that regions like China's Hong Kong and Taiwan maintained positions within the top three worldwide, contrasting starkly with the United Kingdom, which ranked beyond the top ten. Similarly, another internationally recognized assessment, the Trends in International Mathematics and Science Study (TIMSS), yielded analogous outcomes.

Statistically significantly **above** the OECD average
Not statistically significantly different from the OECD average
Statistically significantly **below** the OECD average

Mean score	Comparison country/economy	Countries and economies whose mean score is not statistically significantly different from the comparison country's/economy's score
575	Singapore	
552	*Macao (China)*	*Chinese Taipei*
547	*Chinese Taipei*	*Macao (China)*, *Hong Kong (China)**
540	*Hong Kong (China)**	*Chinese Taipei*, Japan
536	Japan	*Hong Kong (China)**, Korea
527	Korea	Japan
510	Estonia	Switzerland
508	Switzerland	Estonia
497	Canada*	Netherlands*
493	Netherlands*	Canada*, Ireland*, Belgium, Denmark*, United Kingdom*, Poland, Austria, Australia*, Czech Republic
492	Ireland*	Netherlands*, Belgium, Denmark*, United Kingdom*, Poland, Austria, Australia*, Czech Republic
489	Belgium	Netherlands*, Ireland*, Denmark*, United Kingdom*, Poland, Austria, Australia*, Czech Republic, Slovenia, Finland
489	Denmark*	Netherlands*, Ireland*, Belgium, United Kingdom*, Poland, Austria, Australia*, Czech Republic, Finland
489	United Kingdom*	Netherlands*, Ireland*, Belgium, Denmark*, Poland, Austria, Australia*, Czech Republic, Slovenia, Finland, Latvia*
489	Poland	Netherlands*, Ireland*, Belgium, Denmark*, United Kingdom*, Austria, Australia*, Czech Republic, Slovenia, Finland, Latvia*
487	Austria	Netherlands*, Ireland*, Belgium, Denmark*, United Kingdom*, Poland, Australia*, Czech Republic, Slovenia, Finland, Latvia*, Sweden
487	Australia*	Netherlands*, Ireland*, Belgium, Denmark*, United Kingdom*, Poland, Austria, Czech Republic, Slovenia, Finland, Latvia*, Sweden
487	Czech Republic	Netherlands*, Ireland*, Belgium, Denmark*, United Kingdom*, Poland, Austria, Australia*, Slovenia, Finland, Latvia*, Sweden
485	Slovenia	Belgium, United Kingdom*, Poland, Austria, Australia*, Czech Republic, Finland, Latvia*, Sweden
484	Finland	Belgium, Denmark*, United Kingdom*, Poland, Austria, Australia*, Czech Republic, Slovenia, Latvia*, Sweden, New Zealand*
483	Latvia*	United Kingdom*, Poland, Austria, Australia*, Czech Republic, Slovenia, Finland, Sweden, New Zealand*
482	Sweden	Austria, Australia*, Czech Republic, Slovenia, Finland, Latvia*, New Zealand*, Germany
479	New Zealand*	Finland, Latvia*, Sweden, Lithuania, Germany, France

Figure 1. Comparing countries and economies' performance in mathematics
Source: OECD, PISA 2022 Database, Table I.B1.2.1.

Further exploration on the "World Mapper" website regarding the geographical distribution of Nobel Prize laureates reveals a disparity. Despite the absence of a Nobel Prize specifically designated for mathematics, a scrutiny of Nobel Prizes in physics, chemistry, and economics—fields intimately intertwined with mathematics—illuminates a pronounced predominance of laureates from Europe over Asia, particularly China. Moreover, an inquiry into the esteemed "Nobel Prize of Mathematics," the Fields Medal, unveils that, as of 2022, a mere two Chinese mathematicians have been honored among the 65 laureates worldwide, with most awardees hailing from the United States and Europe.

This compilation of observations provokes a fundamental question: how should the effectiveness of an education system be delineated? It becomes apparent that the disparities arising from different educational paradigms do not necessarily signify right or wrong; hence, the definition of such "effectiveness" remains elusive. Consequently, what divergences between Chinese and British mathematics education engender the phenomenon? From the perspective of a Chinese education researcher, what recommendations could be proffered to ameliorate the current state of mathematics education in China?

This paper aims to scrutinize and compare the mathematics education systems of China and the United Kingdom, with a specific focus on primary and secondary school mathematics instruction. Through this comparative analysis, insights will be gleaned to inform potential avenues for improvement.

2. Primary and secondary math education in China and the UK

2.1. Materials and methods

The author has gathered papers from the scientific database “Springer”, as well as additional sources from the reference lists of some of the papers found through the database searches. Using the keywords “Chinese and British mathematics education”, the search yielded 863 results. Of these 863 papers, those including international and comparative education and those related to junior high school mathematics class were selected, based on title, abstract and applicability to the research question.

Next, I will introduce some of the differences in elementary school mathematics education between China and the UK, based on the content of the literature, the information I have reviewed, and my own personal experiences.

2.2. Secondary school mathematics education in China and the UK

In China, secondary school consists of three years. The statutory age for secondary school education is from 12 to 16 years old. The secondary school mathematics curriculum includes numbers and expressions, equations and inequalities, functions and graphs, geometry and shapes, transformations of figures, statistics, and probability. In the UK, basically, there are two systems: one covering England, Wales and Northern Ireland and one covering Scotland. The two education systems have different emphases. Taking England as an example, secondary education typically consists of five years, known as Key Stage 3 and Key Stage 4. The statutory school age for secondary education, including secondary school, is generally from 11 to 16 years old. The secondary school mathematics curriculum in the UK covers a broad range of topics, including number and algebra, geometry and measures, statistics and probability, ratio and proportion, functional mathematics.

Comparing the primary school mathematics curricula between China and England, there are several differences of curriculum standard, the difficulty of mathematics learning content and attitudes toward the application of curriculum standards of schools.

Firstly, the curriculum standard in England emphasizes students’ feelings toward and experiences of mathematics learning, advancing the notion that students need to appreciate the beauty and power of mathematics as a force capable of changing the world (DfE, 2013). In contrast, the national mathematics curriculum of China focuses on developing basic knowledge and skills, learning methods, and learning attitudes (MoE, 2022).

Secondly, the English mathematics curriculum is characterized by a gradual and spiral increase in content and difficulty each semester. While the Chinese mathematics curriculum is similar, this spiraling characteristic is less pronounced. Meanwhile, the Chinese curriculum is more difficult, forcing students to concentrate on the more complex content and placing a relatively heavy academic burden on students (Shi & Pinky, 2023).

Thirdly, In China, the curriculum standards provide the guidelines for teaching in Shanghai schools, with Chinese schools obeying these curriculum standards and adopting the national curriculum. In contrast, English schools use the curriculum standards to guide curriculum design and planning, with each school enjoying considerable leeway in terms of their mathematics curriculum (Shi, 2019).

In the following paragraphs, I will introduce two cases to show the differences more clearly.

2.3. PISA draws international attention to Chinese secondary school mathematics

Every 3 years, the Organization for Economic Cooperation and Development (OECD) tests the knowledge and skills of 15-year-old students worldwide via PISA. PISA measures students' attainment of some of the knowledge and skills essential for full participation in the knowledge society (OECD, 2005a). These results were used to rank participating countries' education systems, providing each country with a comparative analysis of their 15-year-old students (Paine & Schleicher, 2011). These test results aided countries in learning about the quality of teaching and learning in their schools (AlKaabi et al., 2022).

In the past few decades, Asian education has long been regarded as a symbol of "blame and torture" by Western developed countries because it has been labeled as excessive learning, rote memorization, competition-based and so on (Waldow et al., 2014). However, as the scale of the PISA test expanded, China participated in the PISA test in 2009. Shanghai ranked first in three subjects for the first time. This phenomenon is known as the "Shanghai Miracle" and had attracted global attention. The stereotypes of Asian basic education are gradually being shaken with their outstanding performance. In subsequent assessments conducted in 2012 and 2018, China still secured the top position in mathematics, as illustrated in Figures 2 and 3.

	Mathematics			
	Mean score in PISA 2012	Share of low achievers in mathematics (Below Level 2)	Share of top performers in mathematics (Level 5 or 6)	Annualised change in score points
OECD average	494	23.1	12.6	**-0.3**
Shanghai-China	613	3.8	55.4	**4.2**
Singapore	573	8.3	40.0	**3.8**
Hong Kong-China	561	8.5	33.7	**1.3**
Chinese Taipei	560	12.8	37.2	1.7
Korea	554	9.1	30.9	1.1
Macao-China	538	10.8	24.3	**1.0**
Japan	536	11.1	23.7	0.4
Liechtenstein	535	14.1	24.8	0.3
Switzerland	531	12.4	21.4	0.6
Netherlands	523	14.8	19.3	**-1.6**
Estonia	521	10.5	14.6	0.9
Finland	519	12.3	15.3	**-2.8**
Canada	518	13.8	16.4	**-1.4**
Poland	518	14.4	16.7	**2.6**
Belgium	515	18.9	19.4	**-1.6**
Germany	514	17.7	17.5	**1.4**
Viet Nam	511	14.2	13.3	m
Austria	506	18.7	14.3	0.0
Australia	504	19.7	14.8	**-2.2**
Ireland	501	16.9	10.7	-0.6
Slovenia	501	20.1	13.7	-0.6
Denmark	500	16.8	10.0	**-1.8**
New Zealand	500	22.6	15.0	**-2.5**
Czech Republic	499	21.0	12.9	**-2.5**
France	495	22.4	12.9	**-1.5**
United Kingdom	494	21.8	11.8	-0.3

Figure 2. Snapshot of performance in mathematics

Source: OECD, PISA 2012 Database; Tables I.2.1a, I.2.1b, I.2.3a, I.2.3b.

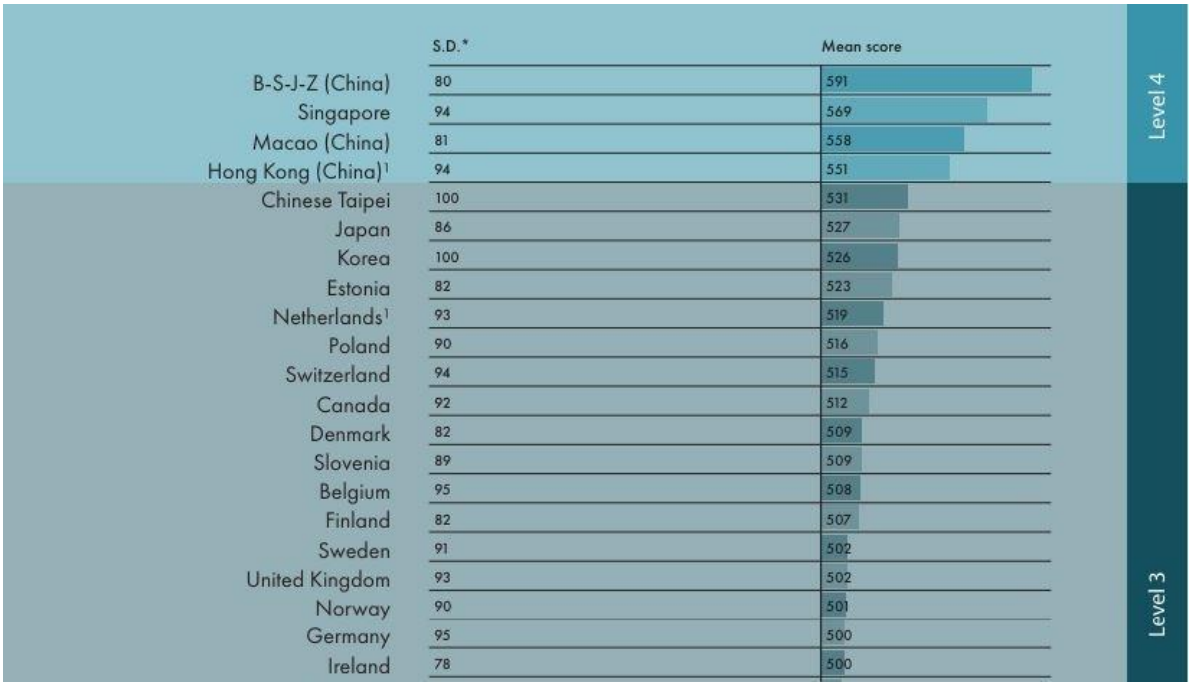


Figure 3. Comparing countries and economies' performance in mathematics

Source: OECD, PISA 2018 Database, Table I.B1.5; Figure I.4.2.

But in 2015, China only ranked number 5 in mathematics.

In comparison, the rankings of British students in mathematics have consistently declined in the PISA assessments from 2003 to 2015. In the first round of PISA assessment in 2000, British students achieved top ten in mathematics. However, in the second round of PISA assessment in 2003, the UK's performance dropped sharply. Due to the low response rate of students, the results of England were not announced and of course there was no ranking. This even attracted criticism and dissatisfaction from the OECD. In the third round of PISA assessment in 2006, although the UK's performance did not decline significantly, its best science performance was only higher than the OECD average. In the fourth round of PISA assessment in 2009, British students' scores continued to decline. The results of the fifth round of PISA assessments in 2012 show that British students' performance in various areas is basically the same as in 2009. Although the number of participating countries and regions in the PISA assessment has increased from the original 43 to 65, the ranking of British students' assessment results has not changed much. On the other hand, it also shows that there is no room for decline in the PISA assessment scores of British students (CHEN, 2016). For the detailed rankings of mathematics of the UK in each PISA assessment, see Table 1.

Table 1. The ranking of UK 15-year-olds in previous PISA maths tests

ranking / year	mathematics
2000	8
2003	-
2006	24
2009	28
2012	26
2015	27
2018	18
2022	11

However, we can observe that the ranking of Britain has improved since 2018, a trend that seems to be associated with the educational reforms in the country. For example, in 2010, the British government promulgated "The Importance of Teaching", proposing the importance of teacher quality

to the quality of the entire school education, and the need to create a world-class school education system to remain invincible in future international competition (DfE, 2010). In 2012, The UK began to implement the new Teachers' Standards, and at the same time implemented some new teacher incentives to help schools introduce and retain excellent teachers, and began to implement the new national curriculum nationwide in September 2014.

It is worth noting that the PISA assessment is not simply an examination of students' academic performance, nor is it an educational competition (CHEN, 2016). It is also not intended to determine which country's educational model is superior. Instead, its purpose is to strengthen connections within the global education community, to learn from and draw on the best educational methods and policies from different countries, and to provide robust data to support policy improvements. Therefore, we should view the PISA results rationally and focus on using large-scale data to analyze the specific reasons behind the assessment outcomes from multiple dimensions.

After obtaining the relevant data on students' grades, the educational sectors and educators in both China and the UK have devised corresponding measures. Next, I will introduce a project, fully funded by the UK Department for Education, which facilitates collaborative exchanges among primary and secondary school teachers. This project aims to further elucidate the differences in mathematics education between Chinese and British elementary schools.

2.4. China-England Mathematics Teachers Exchange (MTE) Program

The UK's performance in previous PISA assessments has declined, while Shanghai students have continued to top the list. This has led the UK and China to launch the "China-England Mathematics Teacher Exchange Program". In the first phase of the project, the British Ministry of Education selected outstanding mathematics teachers to study in Shanghai and summarized the advantages and "secrets" of Shanghai mathematics education (Zhang, 2014), and hoped to carry out reforms in student learning, classroom teaching and teacher education.

From 2011 to 2013, the two schools organized collaborative exchanges between primary and secondary school teachers from the UK and Shanghai. In February 2014, the then British Minister of State for Education, Elizabeth Truss, visited Shanghai for an inspection and decided to elevate the exchange activities between the two schools to the level of a "Mathematics Teacher Exchange" between the governments of both countries, with the British Department for Education covering all expenses. In April 2014, China and the UK signed the "Agreement on Mathematics Teacher Exchange" in Beijing, agreeing to send teachers to each other's countries for study and visits every year, and entrusted Shanghai Normal University to implement the program. From 2014 to 2019, over 520 mathematics teachers have been exchanged between China and the UK, involving more than 400 schools, and the number of British teachers participating in the MTE Program has exceeded 40,000(Huang et al., 2019).

Through this project, we discovered significant differences of mathematics education between China and the UK. In its first evaluation report, the University of Sheffield summarized the differences of mathematics classroom practices in China and England. The detailed results are shown in the table below.

Table 2. Differences in classroom practices

	Shanghai	England
Teaching approach and purposes	Whole-class interactive teaching, brisk tempo to cover multiple small steps, focus on questioning, mini-plenaries, teaching for variation, mathematical talk an instructional priority, emphasis on correct mathematical language.	Explanation through teacher transmission (quick pace) plus individual group practice (slower pace), start from objectives, plenary at end of lesson if at all.
Lesson content and purpose	Focus on specific content in a lesson including all small steps, mastery before moving on, start from mathematical content or problem, teaching for conceptual understanding and procedural fluency. Differentiation through extension/deepening rather than acceleration, the whole class progresses together.	Maximize content covered in a lesson, differentiated learning objectives, spiral curriculum, meeting objectives to progress through levels. Differentiated learning objectives and activities, low attaining pupils progress more slowly, higher attaining pupils accelerated.
Materials, models and resources	Textbooks that are aligned with curriculum support teaching with variation, variety of mathematical models and visual images used to support teaching through variation by careful choice of examples and practice questions.	Variety of resources and materials, often worksheets, use of manipulables7 with younger pupils, usually one model or visual representation used per topic/concept.

Source: Boylan et al., Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England., Table 2.

Through this table, we can see that in Shanghai, the teaching approach is interactive and fast-paced, with a strong emphasis on questioning and correct mathematical language. The results of the TALIS 2018 survey also show that Shanghai teachers score significantly higher than their British counterparts in terms of teaching clarity and cognitive stimulation (Zhu & Xu, 2019). Lessons focus on mastering specific content in small steps, ensuring deep understanding before progressing, and the whole class moves together. Resources include curriculum-aligned textbooks with varied models and visuals to support learning. In contrast, England's approach combines quick teacher explanations with slower individual and group practice, driven by specific objectives. Because British teachers give students more freedom and encourage them to express their opinions during class, they exhibit more classroom management behaviour issues. On the other hand, British teachers also provide more immediate feedback and personalized guidance to students during lessons (Zhu & Xu, 2019). Lessons aim to cover maximum content with differentiated objectives, allowing students to progress at varied rates. Resources often include worksheets and manipulatives, typically using a single model or visual representation per concept.

The PISA results and the MTE program have revealed some characteristics and advantages of China's basic education. These methodological differences are reflective of broader educational goals: China’s collective advancement versus the UK's individualized progress. However, they have also highlighted common issues within the system. Emphasizing the collective while neglecting individuality has led to a situation of "high averages and low variance," which inevitably limits the development of students' individuality, creativity, and critical thinking. Without reflection and improvement, this could result in "winning in grades but losing in education." (CHEN, 2016). Therefore, we need to recognize and preserve our strengths while also acknowledging our shortcomings in a timely manner and learning from the best practices of other countries.

Finally, I will summarize the content and provide some personal perspectives.

3. Discussions

In conclusion, this comparative analysis highlights that no single education system can be deemed universally superior. Each system has its strengths and areas for improvement. The key lies in

continuous reflection and adaptation, learning from global best practices while remaining attuned to local contexts and needs. For China, this means maintaining its high academic standards while also fostering an environment that encourages creativity and critical thinking, ensuring a more comprehensive development of its students.

From the above comparative study of primary and secondary mathematics education in China and the UK, the following issues can be identified:

(1) China's mathematics curriculum focuses on rigorous content mastery and procedural fluency, demanding high academic standards and intensive student effort. This approach is effective in achieving high test scores but may contribute to a high-pressure learning environment. Conversely, the UK's curriculum promotes a broader educational experience, fostering appreciation of mathematics' beauty and its practical applications, albeit with less focus on intensive academic performance.

(2) Precisely because of this teaching model, it is more difficult for China's mathematics education to identify and nurture gifted students in mathematics. Most of the training for these gifted students is still focused solely on mathematical Olympiad training, making it hard to achieve interdisciplinary integration and comprehensive development. This results in mathematically gifted children being unable to fully realize their potential and reach further in their fields.

Ultimately, defining the effectiveness of an education system requires a balanced view that considers both quantitative metrics and qualitative outcomes. An effective education system should not only produce high test scores but also nurture well-rounded individuals capable of critical thinking and creativity. Thus, while China’s focus on rigorous academic standards has its merits, integrating aspects of the UK's more holistic approach could potentially enhance the development of students’ broader competencies.

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